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Educational Objectives
This article will review the principles of root canal obturation and obturating materials currently available.

Upon completion of this course, the dental professional will be able to:
1. Know the main factors influencing endodontic success
2. Know the advantages and concerns around the use of gutta percha
3. Know the options available for root canal obturation and how these differ
4. Know the characteristics of recently introduced carrier-based obturators and their clinical application.

Abstract
Endodontic materials and techniques have advanced dramatically in the last two decades. Historically, gutta percha together with sealer has been the obturation of choice. Gutta percha is versatile, with a long history of use. However, it is not able to bond to obturating materials or to the tooth. Techniques for obturating root canals include the use of heat or chemically-softened gutta percha, injection techniques, ultrasonics, vibration and carriers. Carrier-based materials are available that utilize a core carrier around which obturating material is coated. The introduction of bonded obturating materials (methacrylate resins) has enabled the clinician to obtain a bonded seal to the root canal dentin in areas reached by the etch/adhesive materials. In addition, a carrier-based system is now available that combines a carrier technique and adhesive technology for bonded obturation.

Introduction
Root canal treatment in the mid-1700s included the use of poultices, leeches, and pulpal cauterization. Since that time, much has changed. During the last two decades alone, the science and practice of endodontic therapy have advanced dramatically with the introduction of evidence-based and validated protocols as well as modern techniques and materials. These have paralleled advances in other disciplines. The introduction of surgical operating microscopes, the use of rotary nickel titanium instruments and, within the last year, twisted nickel titanium instruments, research on irrigants and smear layer removal, and the introduction of advanced bonded obturation and sealer materials and techniques have all played a role and continue to do so.

The final step in endodontic therapy is root canal obturation with the objectives of attaining apical and coronal seals, sealing lateral and accessory canals, and consistently filling all pathways from the root canal system to the surrounding periodontal ligament. Prior to obturation, the canals must be adequately cleaned such that they are free of debris and disinfected to remove microbes, and the shape of the prepared canals must enable clinically acceptable obturation. Removing the smear layer with an appropriate product prior to obturation reduces subsequent microbial leakage through the root canals.

It is important to note that the final restoration must provide excellent coronal seal; when a build-up is required it should be performed using a rubber dam to prevent contamination, and the seal created by the obturation materials must not be disturbed.

Hommez et al. reported that inadequate coronal restorations resulted in a 49.1% incidence of apical periodontitis versus 23.8% for those teeth with an adequate coronal restoration, underscoring the importance of the final restoration for clinical success. Research has shown that periradicular lesions are prevalent in teeth with poor coronal restorations; and that the quality of obturation is the most critical factor. The success of endodontic therapy and the long-term viability of the tooth are compromised if any step in the endodontic and restorative procedure is inadequate (Figure 1).

Obturing for Successful Outcomes
Root canal obturation must be complete, fill all main canals to full length to provide an apical seal, and fill all accessory canals. Obturation that is of inadequate length or non-homogenous has been associated with a significantly increased presence of periapical disease assessed within one year post treatment. Until recently, lack of a coronal seal or disturbing the coronal seal during restoration have been problems for root canal therapy even where the obturation was otherwise clinically acceptable.

Gutta percha combined with use of a sealer was historically the standard for root canal obturation. The introduction of obturation materials that can be bonded to root canal dentin and the use of bonded materials for coronal dentin have enabled improved coronal seals that are less susceptible to being compromised during restoration. In addition, the introduction of new thermoplastic techniques and carrier-based obturating materials provide the clinician with more options during obturation.
**Gutta Percha**

Gutta percha offers a number of advantages and disadvantages as a root canal obturating material. Advantages include biocompatibility, ability to be heated and softened for canal placement, compatibility with sealer materials, and technique flexibility. It can be used with sealer coated on it, after sealer is placed in the canal, using an injection technique, used with a carrier, compacted, and placed with vibration and ultrasonics, and it is flowable. Gutta percha is also relatively inexpensive and readily available, has a long history of use, and can usually be readily removed from root canals in cases requiring retreatment. Nonetheless, there are some concerns with gutta percha. Gutta percha does not provide a seal, irrespective of the placement technique, and must always be used with a sealer. Further, if the gutta percha has been heated prior to placement, it can shrink as it cools. Use of gutta percha has been found to create the potential for significant voids if a lateral condensation technique is used. Voids would be more likely to occur with use of an inadequate amount of sealer. Lastly, it bonds neither to the root canal dentin nor to the accompanying sealer, nor does it influence the coronal seal (Table 1). Excellent coronal seal is a key factor in endodontic success, and is not influenced by the presence or absence of gutta percha.8-13

<table>
<thead>
<tr>
<th>Advantages</th>
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<tbody>
<tr>
<td>Long history of use</td>
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<tr>
<td>Biocompatibility</td>
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<tr>
<td>Flexibility of technique</td>
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<tr>
<td>Thermoplastic</td>
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<td>Compatibility with sealers</td>
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<tr>
<td>Easily removed</td>
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<td>Inexpensive</td>
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<table>
<thead>
<tr>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>Provides no seal</td>
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<tr>
<td>Inability to bond to dentin</td>
</tr>
<tr>
<td>Inability to bond to sealers</td>
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<tr>
<td>Shrinks upon cooling</td>
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<tr>
<td>Potential for voids</td>
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<td>Must be used with a sealer</td>
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Compounds that have been used as sealers in conjunction with gutta percha include calcium hydroxide, calcium phosphate, zinc oxide eugenol, AH Plus (epoxy resin), and, more recently, methacrylate resin sealers. Sealers fill voids between gutta percha points when multiple points are used, and are responsible for obtaining apical and coronal seals and the sealing of accessory canals to prevent microleakage and recontamination. Therefore, they are all factors in endodontic success.14

Resin sealers based on adhesive technology bond to root canal dentin when appropriately used. Ideally, if a resin-based sealer is used it should also be able to bond to the selected root canal obturating material. If the obturating material is gutta percha, such bonding cannot occur.

**Resin-Bonded Obturating Materials and Sealers**

AH Plus is an epoxy-based resin sealer. Resin-bonded obturating and sealer materials include EndoREZ® and RealSeal™ (also distributed as Resilon®/Epiphany®) (Figures 2, 3, and 4). These are methacrylates. Neither epoxy resin nor methacrylate resin sealers can be bonded to gutta percha.

![Figure 2. EndoREZ®](image)

![Figure 3. Resilon®/Epiphany®](image)
Both RealSeal™ and EndoREZ® are hydrophilic and are used in the presence of a slightly moist root canal environment. EndoREZ® consists of urethane dimethacrylate with zinc oxide, barium sulfate, resins, and pigments. It is a two-component sealer that is used in conjunction with gutta percha points. EndoREZ® can be placed in the root canal, followed by gutta percha points or resin-coated gutta percha points. EndoREZ® has been found to result in deep dentin tags when bonded to slightly moist root canal dentin and to have good clinical success when the manufacturer’s instructions are followed.15

RealSeal™ and sealer have been licensed from Resilon® and are identical to Resilon® obturating points and Epiphany® sealer. RealSeal™ obturating points and the self-etch sealer are used as a system and require prior removal of the smear layer. Optionally, primer can be used as well. The primer consists of an acidic monomer in water, and the RealSeal™ points are composed of polyester polymers, methacrylate resin, bioactive glass, and radiopaque fillers. The sealer consists of BisGMA, UDMA, EBPADMA, PEGDMA, silane-treated barium borosilicate glasses, peroxide, amines, pigment, stabilizers, barium sulfate, silica, bismuth oxychloride, calcium hydroxide, and photo initiator.

By removing the smear layer with EDTA as the final step in canal preparation, the dentinal tubules are exposed to the primer (Figure 5). Once the self-etch primer has been applied, a monoblock layer is created when the RealSeal™ is inserted (Figure 6). This results in a bonded obturation with a contiguous structure from within the dentinal tubules to the core of the obturating material, with true sealing off of the canal possible where the primer and RealSeal™ contact the desmeared dentin of the canal wall. RealSeal™ is highly opaque and nontoxic.

RealSeal™ can be handled almost identically to gutta percha. It can be used with a lateral or vertical condensation technique, can be compacted, and can be used in an Obtura gun (Spartan Obtura, Fenton, MO) and injected into the canal instead of used as points. An Elements Obturation Unit™ (SybronEndo, Orange, CA) can be used to heat the material and place it, using disposable cartridges and the SystemB obturating technique.
Since handling Resilon® is essentially the same as handling gutta percha, this removes the need to learn a new technique. RealSeal™ (Resilon®) has been found in a number of studies to reduce microleakage in comparison to gutta percha and several different sealers, including AH Plus.16-19 Based on the author’s clinical experience as well as evidence in the literature, use of RealSeal™ offers good clinical success rates.20

In addition to improved sealing ability and the potential for reduced microleakage, resin sealers may offer the potential for increased resistance to root fracture. There are conflicting reports in the literature. Texeira et al. found that RealSeal™ (Resilon®) offers superior resistance to root condensation technique.21 A second study found that both RealSeal™ (Resilon®) and EndoREZ® increased resistance to vertical fracture.22 Other studies, however, have found no improvement or reduced fracture resistance compared to more traditional obturating materials.23-25

**Carrier-Based Obturation**

Carrier-based obturation materials provide a vehicle for delivery of the root canal filling material in one step. These materials are either delivered cold or thermosoftened. It has been claimed that using a carrier-based system is easier than using other obturation techniques, although this may be due to individual variations, experience, and preferences. Irrespective of the method of obturation, appropriate cleaning and shaping of the root canal(s) will determine both the success and ease of obturation for a given canal.

Products that fall under the carrier-based category include Densfil (Dentsply, Maillefer N.A., Tulsa, OK), Pro-System GT® Obturators (Dentsply, Tulsa Dental, Tulsa, OK), Soft-Core® (Soft-Core® Texas, Inc., North Richland Hills, TX), Successfil (Hygienic-Coltene-Whaledent, Inc., Akron, OH), and Simplifill (Discus Dental, Culver City, CA). All these carrier-based systems utilize gutta percha and, with the exception of Simplifill, involve thermosoftening of the gutta percha with the carrier remaining in the canal as an integral part of the obturating material. Simplifill is a cold carrier and involves removing the carrier after it has been used as a delivery vehicle for the obturation material. Simplifill is used after preparing the canal(s) with LightSpeed instruments (Discus Dental) and matching the carrier to the file used to working length. Only the apical portion of the carrier has a coating of gutta percha or Resilon®. This technique can be used with a conventional sealer or a resin-based sealer such as RealSeal™ or EndoREZ®. Stein et al. found that a technique using a Simplifill/gutta percha master cone resulted in no apical dye leakage in in vitro testing.26

**Thermafil**

The original Thermafil® was introduced in the United States as a metal carrier coated with gutta percha. Contemporary Thermafil® is available under the name Thermafil® Plus and has a flexible plastic carrier. Thermafil® Plus is available in a variety of tapers, lengths, and tip sizes. Both the old metal and new plastic carrier systems have been found to be biocompatible, and equivalent in microleakage testing.27-30

Thermafil® (Figure 8) is used by first ascertaining the required length of the carrier for the canal, using the mm markers to set it to this length. The carrier is then heated in the heater and placed into the canal. Insertion of the carrier should take less than 10 seconds to optimize obturation and avoid reduced fill of the canal. Levitan et al. found that a rate of insertion of 18 mm/second resulted in overextension (extrusion) of the fill, while underfill resulted from a rate of insertion of 3 mm/second. In general, the length of fill decreased with decreasing speed of insertion.31 Insertion without twisting is important to avoid removal of the thermoplasticized gutta percha from the core.32 One potential disadvantage is denudation of the core with stripping and removal of the gutta percha coating.33 This would result in voids and inadequate filling of the root canal that may not be visible on a radiograph.

**Successfil**

Successfil utilizes a syringe system, with the pre-measured carrier length inserted into the syringe prior to extrusion of A number of studies have found Thermafil® superior to a lateral condensation technique, while other studies have found the lateral condensation technique superior.34 Two studies compared speed of obturation and found Thermafil® to be the quicker of the two techniques, while a third found no difference in the time taken.35-37 Similarly conflicting results have been found across studies comparing Thermafil® to warm thermoplastic obturation techniques. Apical extrusion of Thermafil® during obturation is found with its use.38 As with other carrier-based systems, care must be taken to avoid extrusion. The increased in temperature at the root surface using Thermafil for obturation has been found to be up to 4.87 °C, depending on the root surface measured, and it has been concluded that use of Thermafil would not result in damage to the periodontium.39 Bonding adhesive resin technology cannot be used to adhere to Thermafil®.
the gutta percha onto the carrier and subsequent insertion into the canal and completion of obturation. This technique offers flexibility with respect to the shape and amount of gutta percha extruded onto the carrier.

Endodontic Retreatment
Endodontic (non-surgical) retreatment is necessary if apical periodontitis recurs. If obturation involves the use of retained carriers, the carrier must be removed together with the sealer and gutta percha coating. For Thermafil®, this can be achieved using heat or a solvent to soften the gutta percha, then a rotary nickel titanium file. If Thermafil® Plus was used, solvent can be used for the plastic core instead of a rotary file, provided the carrier was at a minimum size 45. With smaller-diameter Thermafil® (sizes 40 and below), the carriers are mechanically removed. An in vitro study assessing mechanical removal of size 30 Thermafil carriers from mandibular molar root canals found that removal took 1 minute and 28 seconds using size 25 tapered files at 1500 rpm. Whether or not a carrier-based technique is used, gutta percha and sealer must be completely removed. An in vitro study assessing mechanical removal of size 30 Thermafil carriers from mandibular molar root canals found that removal took 1 minute and 28 seconds using size 25 tapered files at 1500 rpm.40 Whether or not a carrier-based technique is used, gutta percha and sealer must be completely removed and the canals recleaned and reshaped during non-surgical retreatment. Standard gutta percha can be removed using heat, solvents, or files, or a combination of these.

Carrier-Based Resin-Bonded Obturation: RealSeal One™
Until recently, no carrier-based system existed that would enable the use of bonding adhesive technology. With the introduction of RealSeal One™ Bonded Obturators (RSOne), a carrier-based bonded obturating material is available (Figure 9). RSOne contains a radiopaque core of polysulfone coated with RealSeal™. Since the RSOne is one injection-molded unit, the core is always centered in the obturating point. This enables placement with the core centered and an even layer of RealSeal™ available around it to bond to the sealer- as with other techniques, care must still be taken to place the carrier centrally in the canal. Only methacrylate sealer can be used – all other sealers are contraindicated. RSOne should be used with RealSeal SE™ self-etch dual cure resin sealer.

Figure 9. RealSeal One™

The final prepared canal should be tapered appropriately from the orifice to the minor constriction in a manner that optimizes irrigation and obturation but does not put the root at risk of vertical fracture or other iatrogenic events. The selected Size Verifier should have a passive and loose fit and match the size of the last file used to working length. The sealer is placed as a thin film using a paper point or suitable root canal instrument. The film of sealer must be thin enough to enable complete seating of the RealSeal One™ point. The sealer’s bond strength is reduced in the presence of sodium hypochlorite or peroxide. It is therefore key that the last step in canal preparation should be to use EDTA followed by sterile water to remove any traces of these and the smear layer. The use of alcohol should also be avoided, as it would dry out the canal – RealSeal™ (Resilon®) is hydrophilic, and a slightly moist canal is required for optimal bonding strength and sealing of methacrylate resin sealers. RSOne is heated by placing it in the RealSeal™ oven, with the handle on top of the holder and the rubber stop below the holder. After the obturator is heated for the appropriate length of time (30 to 75 seconds, depending on its width), it must be placed in the canal within 6 seconds before it cools to enable complete placement.

If the canal is short, it is possible to trim the coronal portion to match the length of the RealSeal™ to the length of the root canal. If a multi-canal tooth is being treated, placing a paper point or cotton wool pledge over the other canals that still require obturation will prevent the excess material from entering these canals. As with all obturation techniques, upon completion, a radiograph is taken to check the obturation. If the canal is completely filled, as long as the coating material obturated the canal to the working length even if the core of the obturator did not, obturation is complete. Conversely, if the radiograph shows incomplete fill, the obturating material should be removed, files used to reclean the canal, and the obturation reworked. Upon completion of obturation, light curing of the external surface of the RSOne will provide a coronal seal of up to 1 mm depth; the material in the length and depth of the canals will take approximately 45 minutes to completely cure.

Should retreatment be necessary, the obturation material, including the core, can be removed using solvent. The core can be dissolved in up to 8 minutes. One set of in vitro tests found that dissolution occurred in 1-3 minutes. Under laboratory conditions, the average time required to retreat a canal that had been obturated using RSOne was 6.23 minutes.41 The obturating material can be removed by using the solvent or a small amount of chloroform and rotary and Hedstrom files.

A recent in vitro study comparing the use of RSOne, Thermafil® with sealers (Securaseal), and Onestep with Securaseal found that RSOne resulted in significantly less microleakage; under the conditions of the test, only
RSOne demonstrated adequate sealing ability at 90 days. It was concluded that the new material had excellent sealing ability under test conditions. It can be expected that RSOne will provide the same benefits as RealSeal™ and Resilon®, with the potential for reduced microleakage, and a monoblock bonded obturation of the root canal(s). The cases below show the clinical results using carrier-based bonded obturation.

**Clinical Cases**

Figure 10. Upper first molar treated with RealSeal One™ Bonded Obturator

Figure 11. Lower first molar treated with RealSeal One™ Bonded Obturator

Figure 12. Upper second bicuspid treated with RealSeal One™ Bonded Obturator

**Summary**

The science and practice of endodontic therapy have changed dramatically with the introduction of evidence-based and validated protocols along with highly advanced techniques and materials. Regardless of the method and materials used, appropriate cleaning and shaping of the canal and removal of the smear layer are required prior to obturation.

Root canal obturation should provide an apical and coronal seal and should seal all lateral and accessory canals. Gutta percha together with a root canal sealer has been the obturation material of choice and has a long history of use. Gutta percha is unable to bond to adhesive sealer materials that offer the ability to provide a bonded seal to the root canal dentin to reduce microleakage and recontamination. Bonded root canal sealers and fillers are available as methacrylate resins. Paralleling materials developments, vehicles for the delivery and placement of obturating materials have also evolved, with numerous methods available, including heat, injection, vibration, compaction, ultrasonics, and carrier-based systems. The introduction of a methacrylate-based obturator has resulted in the availability of a carrier-based obturation material that utilizes adhesive technology for obturation and sealing of the root canals.

**References**

32 Ibid.
38 Robinson MJ, McDonald NJ, Mullally PJ. Apical extrusion of thermoplasticized obturating material in canals instrumented with Profile 0.06 or Profile GT. J Endod. 2004 30(6):418-21.
41 Data on file.
42 Gambarini G. Sealing ability of a new obturating material: Epiphany one with Resilon carrier technology. Sapienza Università de Roma. 2007.

Author Profile

Richard E. Mounce, DDS
Dr. Mounce lectures globally and is widely published. He is in private practice in Endodontics in Vancouver, WA, USA. He can be reached at RichardMounce@MounceEndo.com.

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1. Root canal treatment in the mid-1700s included the use of _______.
   a. worms
   b. pulpal cauterization
   c. sea salt
   d. none of the above

2. The final step in endodontic therapy is root canal obturation.
   a. True
   b. False

3. The objective of obturation includes _______.
   a. attaining apical and coronal seals
   b. sealing lateral and accessory canals
   c. filling all pathways from the root canal system to the surrounding periodontal ligament
   d. all of the above

4. Inadequate coronal restoration subsequent to endodontic therapy is one of the factors in endodontic failure.
   a. True
   b. False

5. The standard for root canal obturation has been _______.
   a. silver points with use of a sealer
   b. gutta percha alone
   c. gutta percha combined with use of a sealer
   d. none of the above

6. Advantages of gutta percha include its _______.
   a. biocompatibility
   b. ready availability
   c. technique flexibility
   d. all of the above

7. Gutta percha provides a seal for root canal obturation.
   a. True
   b. False

8. AH Plus is _______ resin based.
   a. methacrylate
   b. epoxy
   c. ethacrylate
   d. none of the above

9. Ideally, if a resin-based sealer is used, it should also be able to bond to the selected root canal obturating material.
   a. True
   b. False

10. Both epoxy resin and methacrylate resin sealers can be bonded to gutta percha.
    a. True
    b. False

11. Removing the dentin smear layer with EDTA as the final step in canal preparation exposes the _______ to the primer.
    a. enamel
    b. dentinal tubules
    c. gutta percha
    d. none of the above

12. Methacrylate-based resin can be used with a lateral or vertical condensation technique.
    a. True
    b. False

13. There are conflicting reports on whether or not methacrylate resin sealers may offer the potential for increased resistance to root fracture.
    a. True
    b. False

14. Carrier-based obturation materials _______.
    a. have yet to be developed
    b. provide a vehicle for delivery of EDTA for smear layer removal
    c. provide a vehicle for delivery of the root canal filler in one step
    d. none of the above

15. The ease of use experienced using a carrier-based system may be due to _______.
    a. individual variations
    b. experience
    c. preferences
    d. all of the above

16. All carrier-based systems utilize gutta percha.
    a. True
    b. False

17. Irrespective of the method of obturation, appropriate cleaning and shaping of the root canal(s) will determine success for a given canal.
    a. True
    b. False

18. All carrier-based systems involve the carrier remaining in the canal as an integral part of the obturating material.
    a. True
    b. False

19. When using Thermafil® Plus, insertion of the carrier taking less than 10 seconds optimizes obturation.
    a. True
    b. False

20. Plastic-core carrier systems have been found to be biocompatible.
    a. True
    b. False

21. If endodontic retreatment is necessary and obturation involved the use of a carrier-based system, the carrier _______.
    a. can be left in position as long as the sealer and coating are carefully removed
    b. must be removed together with the sealer and coating
    c. should be ultrasonically removed in all cases
    d. b and c

22. A methacrylate-based resin carrier-based system exists, enabling the use of _______.
    a. lead-based sealer
    b. bonding adhesive technology
    c. silver points
    d. none of the above

23. Endodontic (nonsurgical) retreatment is necessary if apical periodontitis recurs.
    a. True
    b. False

24. Standard gutta percha can be removed using heat, solvents, or files, or a combination of these.
    a. True
    b. False

25. The bond strength of the sealer used with methacrylate-based carriers is reduced in the presence of _______.
    a. sodium hypochlorite
    b. peroxide
    c. moisture
    d. a and b

26. The use of alcohol to dry out the canal is optimal for bond strength and sealing of methacrylate resin sealers.
    a. True
    b. False

27. Methacrylate-based, carrier-based obturating material cures in approximately _______ minutes of placement into the canal(s).
    a. 15
    b. 30
    c. 45
    d. 55

28. The science and practice of endodontic therapy have changed dramatically with the introduction of evidence-based validated protocols, along with highly advanced techniques and materials.
    a. True
    b. False

29. Vehicles for the delivery and placement of obturating materials have evolved to include _______.
    a. heat
    b. carrier-based systems
    c. injection
    d. all of the above

30. Bonded root canal sealers and fillers are available as _______.
    a. epoxy resins
    b. methacrylate resins
    c. acrylic
    d. all of the above
Current Philosophies in Root Canal Obturation

Educational Objectives
1. Know the main factors influencing endodontic success
2. Know the advantages and concerns around the use of gutta percha
3. Know the options available for root canal obturation and how these differ
4. Know the characteristics of recently introduced carrier-based obturators and their clinical application

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 Objective #4: 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. How would you rate the objectives and educational methods?
   5 4 3 2 1 0

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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