Root Canal Obturation: An Update

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This course was written for dentists, dental hygienists, and assistants.

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Educational Objectives
The overall goal of this article is to provide the reader with information on available materials and techniques for the obturation of root canal systems.

Upon completion of this course, the dental professional will be able to:
1. List the purposes of root canal obturation
2. List the characteristics of gutta-percha used for obturation
3. List and describe the contemporary materials and techniques for obturating root canals
4. List the most widely-used techniques for gutta-percha carrier-based obturation and describe its strengths and shortcomings.

Abstract
Obturation is a critical component of root canal therapy, and must both provide a complete seal for the root canal system and eliminate all avenues of leakage from the oral cavity. Historically, gutta-percha cones have been the standard material of choice for root canal obturation, used together with a sealer/cement. The first gutta-percha carrier-based obturating techniques were developed more than two decades ago. More recently, obturating techniques have been introduced that include resin-based sealers and obturators, syringe-applied heated gutta-percha, and the use of gutta-percha as an outer coating on obturator carriers composed of plastic or metal. It is important to select an obturation technique that offers consistency and is easy to use.

Introduction
Root canal obturation involves the three-dimensional filling of the entire root canal system and is a critical step in endodontic therapy. There are two purposes to obturation: the elimination of all avenues of leakage from the oral cavity or the periradicular tissues into the root canal system; and the sealing within the root canal system of any irritants that remain after appropriate shaping and cleaning of the canals, thereby isolating these irritants. Pulpal demise and subsequent periradicular infection result from the presence of microorganisms, microbial toxins and metabolites, and the products of pulp tissue degradation. Failure to eliminate these etiologic factors and to prevent further irritation as a result of continued contamination of the root canal system are the prime reasons for failure of nonsurgical and surgical root canal therapy.1,2,3,4,5

The importance of three-dimensional obturation of the root canal system cannot be overstated, with the ability to achieve this goal primarily dependent on the quality of canal cleaning and shaping as well as clinical skill. Other factors that influence the ultimate success or failure of each case include the materials used and how they are used. The ultimate coronal restoration of the tooth following canal obturation may loom as the most important goal, for there is reasonable evidence that coronal leakage through improperly placed restorations after root canal treatment and failure of the restorative treatment or lack of health of the supporting periodontium are the final determinants of success or failure in treatment.6,7,8

Figure 1. Factors influencing complete obturation

<table>
<thead>
<tr>
<th>Quality of the cleaning and shaping of the canal system</th>
<th>Skill and experience of the clinician</th>
</tr>
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<tbody>
<tr>
<td>Materials and their usage</td>
<td>Restoration of the tooth</td>
</tr>
<tr>
<td>Health of the supporting periodontium</td>
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Characteristics of an Ideal Root Canal Filling
An ideal root canal filling three-dimensionally fills the entire root canal system as close to the cemento-dentinal junction as possible. Minimal amounts of root canal sealers, most of which have been shown to be biocompatible or tolerated by the tissues in their set state, are used in conjunction with the core filling material to establish an adequate seal. Radiographically, the root canal filling should have the appearance of a dense, three-dimensional filling that extends as close as possible to the cemento-dentinal junction. These standards should serve as the benchmark for all clinicians performing root canal therapy, and it is only through a knowledgeable approach to root canal treatment that quality assurance can be continually demonstrated in the obturation of root canal systems.9,10

The ideal root canal filling
Figure 2a. 3-D filling of the entire root canal space as close as possible to the cemento-dentinal junction
Figure 2b. Radiographically dense fill with absence of voids
While a plethora of materials has been advocated over the last 150 years for root canal obturation, historically, gutta-percha has proven to be the material of choice for successful filling of root canals from their coronal to apical extent. Although it is not the ideal filling material, gutta-percha has satisfied the majority of criteria for an ideal root filling material. The disadvantages of gutta-percha – specifically, its adhesiveness, lack of rigidity, and ease of displacement under pressure – do not overshadow its advantages. In light of its shortcomings, a sealer/cement is always used with gutta-percha. However, regardless of the delivery system or technique used, neither gutta-percha nor sealer/cement alone enables standard-of-care canal obturation. In addition, the available materials and techniques do not routinely provide for an impervious seal of the canal system; all canals leak to a greater or lesser extent. It is recommended that clinicians master multiple obturation techniques and become competent with various root canal sealers/cements, to be able to manage the diversity of anatomical scenarios that may be encountered.11,12

Contemporary Sealers/Cements

The use of a sealer during root canal obturation is essential for success. Not only does it enhance the possible attainment of an impervious seal, it also serves as a filler for canal irregularities and minor discrepancies between the root canal wall and core filling material. Sealers are often expressed through lateral or accessory canals and can assist in microbial control should there be microorganisms left on the root canal walls or in the tubules.13,14,15,16,17,18 Sealers can also serve as lubricants, enabling thorough seating of the core filling material during compaction. In canals in which the smear layer has been removed, many sealers demonstrate increased adhesive properties to dentin in addition to flowing into the patent tubules.19,20,21,22,23,24,25,26,27,28,29 A good sealer should be biocompatible and well tolerated by the periradicular tissues and although all sealers exhibit toxicity when freshly mixed, their toxicity is greatly reduced on setting and all are absorbable when exposed to tissues and tissue fluids. Subsequent tissue healing or repair generally appears unaffected by most sealers, provided there are no adverse breakdown products of the sealer over time. In particular, the breakdown products may have an adverse action on the proliferative capability of periradicular cell populations. Some clinicians consider that a small puff of root canal filler extending beyond the working length is indicative of a fully obturated canal space with a well-sealed apical constriction. Excessive sealer should not be routinely placed in the periradicular tissues as part of an obturation technique.30,31,32,33,34,35,36,37,38,39,40,41,42

Sealers/cements can be grouped based on their prime constituent or structure, such as zinc oxide-eugenol, polyketone, epoxy, calcium hydroxide, silicone, resin, glass ionomer, or resin-modified glass ionomer. However, many of the sealers/cements are combinations of components, such as zinc oxide-eugenol and calcium hydroxide,43 with the addition of calcium hydroxide claimed to create a therapeutic material that can be inductive of hard tissue formation.44,45 Epoxy-based and methacrylate-based resin sealers that can be bonded to the root canal dentin (but not to gutta-percha) are also now available.46

Sealers should be mixed to a creamy consistency, allowing them to adhere to the master cone and not ball up at the shaft of the cone, leaving the gutta-percha exposed. The sealer should adhere to the cone evenly along its length and at the end of the cone. Clinicians should read the product insert and material safety data sheet for each product chosen before using it.

Contemporary Core Filling Materials

Gutta-percha is the standard material of choice as a solid core filling material for canal obturation. It demonstrates minimal toxicity and minimal tissue irritability, is the least allergenic material available when retained within the canal system,47 and in cases of inadvertent gutta-percha cone overextension into the periradicular tissues, is well tolerated provided the canal is clean and sealed. Chemical solvents have been used for almost 100 years to soften gutta-percha, with methods ranging from merely dipping the gutta-percha cones into the solvent for one second for better canal adaptation, to creating a completely softened paste of gutta-percha with the solvent. Solvents used have included chloroform, halothane, rectified white turpentine, and eucalyptol. Periradicular tissues may be irritated if the solvent is expressed beyond the canal or significant amounts of softened gutta-percha are inadvertently placed into the periradicular tissues. Failure to allow for dissipation of chemical solvents, if volatile, or the removal of excess solvent with alcohol can result in significant shrinkage and possible loss of the apical seal. The use of chemical solvents has been both praised and questioned, but with the advent of thermoplasticized gutta-percha, the need to consider the use of solvents at any time must be questioned. The use of solvents, however, may still be considered for a number of challenges the clinician may face in daily practice, such as the custom fitting of master cones in irregular apical preparations or following apexification.48,49,50,51,52,53,54,55,56,57

Gutta-percha Cones

The composition of gutta-percha cones is approximately 19% to 22% Balata and 59% to 75% zinc oxide, with the re-
mainer a combination of various waxes, coloring agents, antioxidants, and metallic salts. The specific percentages for components varies by manufacturer, with resulting variations in the brittleness, stiffness, tensile strength, and radiopacity of the individual cones attributable primarily to the percentages of gutta-percha and zinc oxide. The antimicrobial activity of gutta-percha is also primarily due to the zinc oxide. The cones are manufactured in both standardized and non-standardized sizes. The standardized sizes coordinate with the ISO root canal files sizes 15 through 140 and are used primarily as the main core material for obturation. They generally have a 2% taper, but can have a 4 or 6% taper or more (Figure 3). The non-standardized sizes are more tapered from the tip or point to the top. With some obturation techniques these cones have been used primarily as accessory or auxiliary cones during compaction, being matched with the shape of the prepared canal space or the compaction instrument. Non-standardized cones began to assume a greater role as the primary core material in the more contemporary obturation techniques, and with the development of more predictable shapes with current nickel titanium (NiTi) rotary and hand instruments, cones tapered from 4% to 10% have gained use. In particular, for techniques that use vertical compaction of heat-softened gutta-percha, both the non-standardized and more tapered cones have become quite acceptable. Custom cones can also be developed for canals with irregular or large apical anatomy. Over time, numerous methods have been advocated for obturating the prepared root canal system, each with their own claims of ease, efficiency, or superiority. Most contemporary techniques still rely on gutta-percha and sealer to achieve their goal. Four basic techniques exist for the obturation of the root canal system with gutta-percha and sealer (Figure 4): (1) the cold compaction of gutta-percha; (2) the compaction of heat-softened gutta-percha with cold instruments until it has cooled; (3) the compaction of gutta-percha that has been thermoplasticized, injected into the system, and compacted with cold instruments; and (4) the compaction of gutta-percha that has been placed in the canal and softened through the continuous wave technique (Calamus). A multitude of variations on these four basic themes exists. For injectable thermoplastic obturation techniques, gutta-percha may come in either pellet forms or in cannulae. No single technique has proven to have statistically significant superiority when considering both in vitro and in vivo studies, as the success of all techniques is highly dependent on the cleaning and shaping of the canals and the clinician’s expertise in the use of a particular technique. While many have advocated the use of the lateral compaction technique or a single cone fill (monocone) to achieve a quality apical seal, the technique in itself does not necessarily favor the filling of canal irregularities. Recognizing this, use of a softened gutta-percha technique with heat or chemical softening is required to achieve a thorough obturation. In addition, while filling the entire root canal system is the major goal of canal obturation, a major controversy exists as to what constitutes the apical termination of the root canal filling material. Working length determination guidelines often cite the cemento-dentinal junction or apical constriction as the ideal position for terminating canal cleaning and shaping procedures and placing the filling material. However, the cemento-dentinal junction is a histologic and not a clinical position in the root canal system (Figure 5) and, in addition, the cemento-dentinal junction is not always the most constricted portion of the canal (yellow arrows) in the apical portion of the root (Figure 6).
Contemporary practices of obturation favor material softening; even this does not guarantee that an impervious seal of the root canal system will be established. Also, with softened gutta-percha obturation techniques there has been a greater incidence of material extrusion beyond the confines of the canal. While softening of gutta-percha may be viewed as routinely desirable, the selective use of this technique solely or in combination with a solid core of gutta-percha must be at the discretion of the competent clinician when anatomy dictates this approach.76,77

Recent research conducted at Nova Southeast University using micro CT scanning technology has shown the effectiveness of scanning for imagery and the greater precision observed compared to standard radiographs. In one example, a mesiobuccal canal was filled using GT® Series X™ obturator and the mesiolingual canal was filled using a single cone technique (ActiV GP). It appeared from one angle that all canals were equally filled (Figure 7). However, closer examination subsequent to filling showed voids using the single cone technique throughout the length of the root filled using this technique (Figure 8). The single cone technique did not produce a monoblock obturation (Figure 9). The gutta-percha from the GT obturator flowed into the canal isthmus and filled it (Figure 10).

Differences in obturation techniques and results are also more observable using CT scanning than using traditional radiographs.78 Contemporary techniques include the use of bonded root canal filling materials. Recent developments in resin-bonding have led to the availability of resin cones and
pellets similar in shape and size to gutta-percha materials. Resin-based cones containing methacrylate resin, fillers, bioactive glass, and polymers are available that can be handled similarly to gutta-percha and can be used with a lateral or vertical compaction technique. Resin-based materials can also be delivered via a heated syringe (Obtura gun, Spartan Obtura). Since resin-based materials require a slightly moist environment, it is important to avoid using any dessicating solutions, such as alcohol, during root canal preparation. Further, if sodium hypochlorite or peroxide was used during root canal preparation, this must be thoroughly removed prior to using a resin-based material as it would reduce the ability of the resin material to bond. Similarly, the smear layer must also be thoroughly removed.

Prefabricated Obturators

Gutta-percha can also be formed on a plastic carrier or core-carrier. Prefabricated obturators were first described in 1978 by William Ben Johnson.79 The prototype for the obturator had been prenotched K-files wrapped in gutta-percha (hand formed) that were then heated over a flame until the surface glistened and expanded. These prenotched “obturators” were inserted into the canal and apical pressure applied while the handle was twisted off (Figure 11).

Prefabricated obturators were introduced in 1988 (Thermafil) using first a stainless steel and subsequently a titanium core, coated with gutta-percha. Plastic obturators were first offered in 1992. Since then, a number of prefabricated obturator systems have been introduced, including one that does not involve thermosoftening of the gutta-percha (SimpliFil, Discus Dental) but instead is used cold with only the apical area coated in gutta-percha, and after placement the carrier itself is removed.

A recently developed prefabricated obturator utilizes a resin-based system (RealSeal One, Sybron Endo) and is used with, and bonded to, methacrylate resin-based sealer material and is first held in its custom oven and thermosoftened. Other systems use thermosoftened gutta-percha, including Calamus® (Tulsa Dental, Dentsply) (Figure 12), Successfil® (Hygienic-Coltene-Whaledent, Inc.), Gutta-Flow®, System B Obturation System, Thermafil, Thermafil Plus, ProTaper® Universal and ProSystem GT® Obturators (Dentsply, Tulsa Dental), and Soft-Core® (Soft-Core® Texas, Inc.).

Current plastic obturators are available in a nonvented shape with a taper of around 0.04 (Densfil) and a vented shape with the same taper (Thermafil Plus). Both are biologically inert.80 The carrier is thick with a thinner outer coating of gutta-percha, which helps to reduce material shrinkage as the gutta-percha cools in the canal (Figure 13). A vented prefabricated obturator helps the flow of gutta-percha during placement and also aids in retrieval of the obturator should retreatment be necessary.

For sizes 40 and below in the Thermafil series, an insoluble liquid crystal plastic is used. For size 45 and above soluble polysulfone polymer is used. All of these use a size verifier to help select the correct size obturator, as do ProTaper Universal carriers, which start at a .04 taper. Systems that do not use a size verifier include the ProSystem GT carriers and GT Series X carriers, which are made in a variety of tapers between 0.04 and 0.12.

The first case below shows a step-by-step procedure using GT® Series X™ obturation, and the second shows use of the ProTaper® Universal obturator.

Case 1. GT® Series X™ obturation

Following complete shaping and cleaning, the canals should be thoroughly dried. For the obturator, the size matching the
last instrument taken to working length should be selected (Figure 14). It is vital that the calibration rings (measuring marks) on the carrier are used as opposed to actually measuring the obturator from the tip. There is more gutta-percha than plastic carrier at the apical end of the obturator and it is this gutta-percha that is intended to flow and fill the space ahead of the plastic.

The plastic core delivers the gutta-percha to the full working length. If necessary, for shorter canals, excess gutta-percha should be peeled from the coronal end to facilitate setting of the working length indicator. Additionally, if BioPure® MTAD® is to be used in the canal space, it must be the last liquid irrigant in the canal space and should therefore be incorporated after checking the fit of the size verifiers.

The obturator is then heated in the GT (or GT® Series X™) obturator oven to ensure even heating of the gutta-percha and consistent flow of the gutta-percha in the canal (Figure 15). During the heating process, sealer is placed in the canal space. A non-eugenol sealer is recommended for use with GT® Series X™ obturators, with a thin coat applied using a paper point (Figure 16). After placing the sealer, excess should be blotted out with a paper point. It is critical that only a tiny amount of sealer be used since increasing the amount of sealer will predispose to material overextension beyond the confines of the canal. The obturator is then placed in the canal with a smooth motion until the rubber stopper touches the reference point on the crown of the tooth, indicating it has reached working length (Figure 17). It is important not to rotate the obturator or to push it with excessive force into the canal. Prior to cutting off the handle, the length and quality of the fill can be confirmed with a radiograph. The handle of the obturator can be cut off after several seconds of cooling of the gutta-percha with a Prepi® bur, a round bur, an ultrasonic tip, or a Touch ‘n Heat instrument. If using a Prepi® bur, water spray should not be used as this would needlessly soak the pulp chamber and any other open canals, thereby creating more work in cleanup. Allow for the gutta-percha to cool back to a hard consistency prior to making post space so that the obturator is not dislodged by the post drill; therefore it is recommended to wait five minutes after placement before cutting the obturator.

A ProPost® drill with an eccentric tip can be used to cut the post channel through the obturator (note that most post drills cannot efficiently cut a solid core obturator).

Case 2. ProTaper® Universal/Thermafil® obturator technique

The ProTaper® and Thermafil® Plus obturators are a solid core of plastic covered in a layer of gutta-percha. As in the case above, thorough drying and cleaning of the canals is required. In this case, the obturator is selected using the size verifier to ascertain the size required for a passive fit at working length in the canal (Figures 19,20). For canals shorter than 18 mm, the
carrier can be stripped back from 18 and the rubber stopper repositioned, while for canals longer than 24 mm, the length can be measured on the handle and part of the handle cut back (taking care to preserve half of the handle length so that the obturator can rest on the oven hanger arm). The obturator is heated using the ProTaper® Universal obturator oven, which is designed specifically to guarantee full and uniform gutta-percha heating. A light coating of sealer should be placed to the full working length of the root canal space, then the heated obturator is placed in the canal with a smooth motion until the rubber stopper touches the reference point on the crown of the tooth, indicating it has reached working length. The obturator should not be rotated or pushed into the canal with excessive force. There is adequate time after taking the obturator out of the oven to methodically place the gutta-percha without rushing. The length and quality of the fill can be confirmed with a radiograph prior to cutting off the handle using one of the techniques described above in Case 1. Post space preparation can occur after five minutes.

**Figure 19. Working length indicators**

**Figure 20. Size verifier**

**Figure 21. Finished case**

**Summary**

Appropriate cleaning and shaping of canals and obturation with an apical and coronal seal are essential for successful clinical outcomes in root canal therapy. While gutta-percha cones, used together with a sealer/cement, may not meet all criteria for the ideal root filling material, it has withstood the test of time and is the standard material used for root canal obturation. Contemporary techniques include the use of gutta-percha carrier-based obturators as well as thermosoftened syringed gutta-percha and mechanically softened gutta-percha. Other materials used include resin-based carriers and sealers. For successful outcomes, the appropriate use of the selected materials and techniques, radiographic control during the different phases of endodontic therapy, and a high degree of clinical expertise are required.

**References**

63 Ibid.
65 Grove C. Why root canals should be filled to the deninocemental junction. J Am Dent Assoc. 1939;17:203.

Author Profile
The authors of this course, James L. Gutmann, DDS, Sergio Kuttler, DDS and Stephen P. Niemczyk, DMD, are all board-certified endodontists.
Questions

1. The purpose of root canal obturation is __________.
   a. the elimination of all avenues of leakage
   b. the introduction of a medicament
   c. sealing within the root canal system of any irritants
   that remain after appropriate shaping and cleaning of the canals, thereby isolating these irritants
   d. a and c

2. Pulpal demise and subsequent periapical infection result from __________.
   a. the presence of microorganisms
   b. the products of pulp tissue degradation
   c. the presence of microbial toxins and metabolites
   d. all of the above

3. The ability to achieve three-dimensional root canal obturation is primarily dependent on __________.
   a. clinical skill
   b. the quality of canal cleaning and shaping
   c. the material
   d. a and b

4. There is reasonable evidence that coronal leakage through improperly placed restorations after root canal treatment and failure of the restorative treatment or lack of health of the supporting periodontium are the final determinants of success or failure in treatment.
   a. True
   b. False

5. Maximum amounts of root canal sealers should be used in conjunction with the core filling material to establish an adequate seal.
   a. True
   b. False

6. Gutta-percha has satisfied the majority of criteria for an ideal root filling material, but neither gutta-percha nor sealer/cement alone enables standard-of-care canal obturation.
   a. True
   b. False

7. A disadvantage of gutta-percha is __________.
   a. its ease of displacement under pressure
   b. its lack of rigidity
   c. its adhesiveness
   d. all of the above

8. To be able to manage the diversity of anatomical scenarios that may be encountered, __________.
   a. the clinician should completely master one obturating technique
   b. it is recommended that the clinician master several obturation techniques
   c. scans are required
d. all of the above

9. Use of a sealant is only required if the obturator is not thermoplastic and cannot adequately fill the canal.
   a. True
   b. False

10. Root canal sealers can __________.
    a. enhance the possible attainment of an impervious seal
    b. serve as a filler for root canal irregularities
    c. assist in microbial control should there be microorganisms left on the root canal walls or in the tubules
    d. all of the above

11. In canals in which the smear layer has been removed, many sealers demonstrate reduced adhesive properties to dentin.
   a. True
   b. False

12. All sealers exhibit toxicity when freshly mixed, their toxicity is greatly reduced on setting and all are absorbable when exposed to tissues and tissue fluids.
   a. True
   b. False

13. One sealer/cement combination discussed in the article is zinc oxide eugenol and epoxy resin.
   a. True
   b. False

14. Epoxy-based and methacrylate-based resin sealers that can be bonded to the root canal dentin are available.
   a. True
   b. False

15. Bonding to gutta-percha can be achieved using epoxy-based resins.
   a. True
   b. False

16. Gutta-percha as a solid core filling material for canal obturation __________.
    a. demonstrates minimal minimal toxicity
    b. demonstrates minimal tissue irritability
    c. is the least allergenic material available when retained within the canal system
    d. all of the above

17. __________ is a chemical solvent that has been used with gutta-percha.
    a. Rectified black turpentine
    b. Chloroform
    c. Water
    d. all of the above

18. The use of solvents may still be considered for a number of challenges the clinician may face in daily practice, such as the custom fitting of master cones in irregular apical preparations.
   a. True
   b. False

19. The composition of gutta-percha cones is approximately __________.
    a. 19% to 32% Balata; 59% to 85% zinc oxide
    b. 19% to 32% zinc oxide; 59% to 85% Balata
    c. 19% to 22% Balata; 59% to 75% zinc oxide
d. none of the above

20. With the development of more predictable root canal shapes prepared with current nickel titanium (NiTi) rotary and hand instruments, cones tapered from 4% to 10% have gained use.
   a. True
   b. False

21. Basic techniques for the obturation of the root canal system with gutta-percha and sealer include __________.
    a. cold compaction or heat-softened compaction using cold instruments
    b. compaction of gutta-percha that has been thermoplasticized, injected into the system, and compacted with cold instruments
    c. compaction of gutta-percha that has first been placed in the canal and then softened
    d. all of the above

22. While softening of gutta-percha may be viewed as routinely desirable, the selective use of this technique solely or in combination with a solid core of gutta-percha must be at the discretion of the competent clinician.
   a. True
   b. False

23. Resin-based cones are available that can be used with a __________.
    a. lateral compaction technique only
    b. vertical compaction technique only
c. diagonally-positioned compaction technique only
    d. vertical or lateral compaction technique

24. It is important to avoid using any desiccating solutions, such as alcohol, during root canal preparation if using resin-based obturating materials.
   a. True
   b. False

25. Prefabricated obturators were first described in 1978 by __________.
    a. William Ben Thompson
    b. Ben William Thompson
c. William Ben Johnson
    d. Ben William Johnson

26. Gutta-percha-based and resin-based prefabricated obturators are currently available.
   a. True
   b. False

27. Current tapered plastic obturators are available in nonvented and vented shapes.
   a. True
   b. False

28. A vented prefabricated obturator __________.
    a. helps the flow of gutta-percha during placement
    b. helps the flow of gutta-percha after placement
c. aids in retrieval of the obturator should retreatment be necessary
    d. a and c

29. With a gutta-percha-based prefabricated carrier, if BioPure® MTAD® is to be used in the canal space, it should be the first liquid irrigant used in the canal space prior to checking the fit of the size verifiers.
   a. True
   b. False

30. Radiographic control during the different phases of endodontic therapy is required.
   a. True
   b. False
ANSWER SHEET
Root Canal Obturation: An Update

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Educational Objectives
1. List the purposes of root canal obturation
2. List the characteristics of gutta-percha used for obturation
3. List and describe the contemporary materials and techniques for obturating root canals
4. List the most widely-used techniques for gutta-percha carrier-based obturation and describe its strengths and shortcomings.

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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
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5. How do you rate the author’s grasp of the topic? 5 4 3 2 1 0
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