Modern Perspectives in Root Canal Obturation

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. Understand the requirements for successful obturation of root canals.
2. Be knowledgeable concerning available root canal obturating materials and what constitutes an ideal root canal filling material.
3. Understand the basic techniques and their steps for root canal obturation.
4. Be knowledgeable about the types of devices available for the application of heat and/or vibration during root canal obturation and the rationale for their use.

Abstract
Successful root canal treatment is based on diagnosis, treatment planning, knowledge of tooth anatomy, and the traditional concepts of debridement, sterilization, and obturation. Several obturation techniques are available for root canal treatment. The choice depends on the canal anatomy and the unique objectives of treatment in each case. The two basic obturation procedures are lateral condensation and warm vertical condensation. The advent of new devices and techniques, such as those that utilize heat and vibration for warm lateral and warm vertical condensation, are revolutionizing the practice of endodontics and making obturation procedures more predictable.

Introduction
Successful root canal treatment is based on diagnosis, treatment planning, knowledge of tooth anatomy, and the traditional concepts of debridement, sterilization, and obturation. Adequate access and a straight-line path to the canal system allow complete irrigation, shaping, cleaning, and quality obturation. Root canal treatment can be predictably successful with careful cleaning and shaping of the canal system, three-dimensional obturation, and a well-fitting coronal restoration. Regardless of the obturation method, emphasis has to be placed on the process of cleaning and shaping the root canal, without which obturation will not be effective. Factors influencing the timing of canal obturation are the patient’s signs and symptoms, the pulp and periradicular status, the degree of case difficulty, and patient management.

Final obturation of a root canal that is not completely cleaned and shaped is contraindicated. During the cleaning and shaping process, organic and inorganic debris accumulate on the canal wall, producing an amorphous, irregular smear layer, which may interfere with adhesion and penetration into dentinal tubules of intracanal medication or root canal sealer during obturation. Prior to obturation, the smear layer should be removed and the dentin interface thoroughly dried.

Various experimental methods have been used to assess microleakage following obturation, including the use of radioisotopes, dyes, proteins, bacterial leakage, and endotoxin penetration, as well as the use of electrochemical, fluorometric, and scanning-electron microscopic examination, and spectrophotometry. Using full-mouth radiograph series, endodontic treatment was evaluated in a patient group screened at the University of Connecticut Health Center School of Dental Medicine. Of 5,272 teeth examined, 5.5 percent had root canal obturation. Periapical disease was evident in 4.1 percent of all teeth and in 31.3 percent of root-filled teeth, with the lesser-quality root obtrurations more strongly associated with periapical disease than higher-quality obtrurations. Only 42 percent of obturated canals were considered technically satisfactory. This study highlights the need for improved canal cleaning, shaping, and obturation techniques.

Root Canal Obturating Materials
In 1941, Jasper introduced silver cones. Their rigidity made them easy to place; however, their inability to fill the irregularly shaped root canal system permitted leakage. Silver points were found to corrode, and the corrosion products were found to be highly cytotoxic, thus silver cones are no longer utilized for root canal obturation.

For many years, gutta-percha has proven to be the material of choice for successful obturation when used in combination with a root canal sealer, which is necessary to seal the space between the dentinal wall and the obturating core interface. Sealers also fill voids and root canal irregularities, lateral and accessory canals, and spaces between gutta-percha points used in lateral condensation. Sealers are required for all techniques. Some of the new obturating materials are based on dentin-adhesion technologies, in an attempt to seal the root canal system more effectively and perhaps strengthen the root. However, effective bonding is a challenge due to root canal anatomy and limitations in the physical and mechanical properties of the adhesive materials.

Although there is no ideal obturation material, Grossman outlined the requirements for an ideal root canal filling material. (Table 1)

Gutta-percha has been the most popular core material used for obturation. It can be made to flow using heat or using solvents, such as chloroform or eucalyptus, as well
as by ultrasonics and vibration. It is a trans-isomer of polyisoprene and exists in two crystalline forms (alpha and beta) with differing properties. (Table 2) The use of alpha phase gutta-percha has increased as thermoplastic techniques have become more popular.

Gutta-percha cones consist of approximately 20 percent gutta-percha, 65 percent zinc oxide, 10 percent radiopacifiers, and 5 percent plasticizers. They are available in conventional and standardized sizes. The conventional nomenclature refers to the dimensions of the tip and body (ADA-ANSI No. 26), e.g., a fine-medium cone has a fine tip with a medium body. Standardized cones are designed to match the taper of stainless-steel and nickel-titanium instruments. Size uniformity in manufacturing has improved, and the actual cone size is more precise.27,28 Gutta-percha points can be sterilized before use by placing the cones in 5.25% NaOCl for 1 minute.29

Resin-based obturation systems have been introduced as an alternative to gutta-percha. Resilon is a high-performance industrial polyurethane, adapted for endodontic use. It resembles gutta-percha and can be manipulated similarly. It consists of a resin core material, available in conventional/standardized cones or pellets, and a resin sealer. Resilon is nontoxic, nonmutagenic, and biocompatible. (Figure 2)

Canals with open apices have unique requirements. Calcium hydroxide, dentin plugs, and hydroxyapatite have been advocated for placement as barriers in canals exhibiting an open apex to permit obturation, while minimizing extrusion of materials into the periradicular tissues. Enhanced healing, minimal inflammation, and improved apical cementum deposition have been noted histologically.30 However, teeth treated with calcium hydroxide for prolonged periods have recently been found to be more susceptible to fracture.31 Placement of an apical barrier and immediate obturation is an alternative to apexification. Mineral trioxide aggregate (MTA) has been suggested as an apical barrier material.32,33 An in vitro analysis concluded that Ca++, the dominant ion released from MTA, reacts with phosphates in synthetic tissue fluid, yielding hydroxyapatite. The dentin-MTA interfacial layer results from a similar reaction. MTA is sterile, biocompatible, and capable of inducing hard-tissue formation.34,35 The material is compacted into the apical portion of the root and allowed to set, and then gutta-percha can be compacted without extrusion. (Figures 3, 4) The technique is quick and clinically successful, and eliminates the need for numerous visits and possible recontamination during apexification.36

**Obturation Techniques**

Several obturation techniques are available for root canal treatment. The choice depends on the canal anatomy and the unique objectives of treatment in each case. Lateral condensation and warm vertical condensation of gutta-percha are techniques that have passed the test of time. Newer methods include the use of injectable, thermoplasticized gutta-percha systems; carriers coated with an alpha phase gutta-percha; cold, flowable obturation materials that combine gutta-percha and sealer in one product; and glass ionomer embedded in gutta-percha cones. It is
important to remember that no obturation technique produces a complete hermetic seal.37,38 The two basic obturation procedures are lateral condensation and warm vertical condensation. The methods vary by the direction of the compaction (lateral or vertical).

Lateral Cold Condensation

This technique has been the “gold standard” to which other techniques have been compared. Lateral cold condensation has the advantage of excellent length control and can be accomplished with any of the acceptable sealers.39,40 However, this technique may not fill canal irregularities as well as the warm vertical compaction technique.

A standardized gutta-percha cone is selected with a diameter consistent with the largest file used at working length. Standardized cones (0.02) generally have less taper than conventional cones, and permit deeper spreader penetration. Alternatively, an appropriately tapered conventional cone can be adapted by cutting small increments from the tip. This “master cone” is measured and grasped with a forceps so that the distance from cone tip to forceps is equal to the prepared length. The cone is placed in the canal, and if an appropriate size has been selected, there will be resistance to displacement or “tug back.” If there is no resistance, modifications are required. (Table 3)

Master cone placement is confirmed with a periapical radiograph. Sealer is applied to the canal walls via the last-sized file used at working length. A spreader is selected that matches the taper of the canal. Appropriate accessory points are selected according to the taper of the spreader. Finger spreaders provide better tactile sensation and have been shown to be less likely to induce fractures in the root when compared with the more traditional D11T hand spreader.41 There appears to be a correlation between spreader penetration and the establishment of a seal.42,43 The spreader should fit within 1 to 2 mm of the prepared length, and when introduced into the canal with the master cone in place, it should be within 2 mm of the working length.

After placement, the spreader is removed by rotating it back and forth as it is withdrawn, while being careful not to spear the master point. An accessory cone is placed in the space made by the instrument and the process is repeated until the spreader no longer penetrates beyond the coronal third of the canal. (Figures 5, 6) Excessive force should be avoided—cold gutta-percha is not greatly compressible, and as little as 1.5 kg of pressure are capable of fracturing the root.44

Table 3. Cone size and modifications

<table>
<thead>
<tr>
<th>Cone loose</th>
<th>Remove 1 mm increments from the tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cone fails to go to the</td>
<td>Select a smaller cone</td>
</tr>
<tr>
<td>prepared length</td>
<td></td>
</tr>
<tr>
<td>Cone extends beyond the</td>
<td>Adapt a larger cone or shorten the</td>
</tr>
<tr>
<td>prepared length</td>
<td>existing cone until there is “tug back”</td>
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</table>

After placement, the spreader is removed by rotating it back and forth as it is withdrawn, while being careful not to spear the master point. An accessory cone is placed in the space made by the instrument and the process is repeated until the spreader no longer penetrates beyond the coronal third of the canal. (Figures 5, 6) Excessive force should be avoided—cold gutta-percha is not greatly compressible, and as little as 1.5 kg of pressure are capable of fracturing the root.44
Excess gutta-percha in the chamber is then seared off and vertically compacted with a heated pluggers at the canal orifice, or approximately 1 mm below the orifice in posterior teeth. Warm vertical compaction of the coronal gutta-percha may enhance the seal. In anterior teeth, the desired level is the cemento-enamel junction (CEJ) on the facial surface.

**Use of vibration, heat and ultrasonics**

An alternative to cold lateral compaction with finger spreaders is ultrasonics and, more recently, a combination of vibration and heat using the DownPak Obturation Device (EI, a Hu-Friedy Company, Chicago, IL). One study found that an ultrasonic condensation technique produced adequate obturation and a 93 percent clinical success rate. An alternate to cold lateral compaction with finger spreaders is ultrasonics and, more recently, a combination of vibration and heat using the DownPak Obturation Device (EI, a Hu-Friedy Company, Chicago, IL). One study found that an ultrasonic condensation technique produced adequate obturation and a 93 percent clinical success rate. Lateral condensation can be employed by alternating heat after the placement of each accessory gutta-percha cone; heat can be transferred to the canal to soften the cones for better condensation and homogeneity of both the sealer and the gutta-percha.

**Warm vertical condensation**

Vertical condensation of gutta-percha forms the basis for many techniques, such as the master-cone sectional, warm gutta-percha, and thermoplasticized techniques. A master cone is fitted short of the corrected working length (0.5 to 2 mm) with resistance to displacement. This ensures that the cone diameter is larger than the prepared canal. Conventional cones that closely replicate the canal taper are best because they permit the development of hydraulic pressure during compaction. Following its adaptation, the master cone is removed and the sealer is applied. The cone is placed in the canal and the coronal portion removed by applying heat with a spreader or pluggers that also soften the remaining material in the canal. A pluggers is inserted into the canal and the gutta-percha condenses, forcing the plasticized material apically. The process is repeated until the apical portion has been filled. (Figure 7)

The coronal canal space is back-filled using small segments of gutta-percha by placing into the root 3- to 4-mm sections approximately the size of the canal, applying heat, and condensing the gutta-percha with a pluggers.

In comparing cold lateral and warm vertical condensation techniques, it has been found that a higher percentage of the canal area is filled with gutta-percha in oval canals using the warm vertical condensation technique. In addition, it has been found that the gutta-percha adaptation is improved with deeper heat application. Advantages of the warm vertical compaction technique include movement of the plasticized gutta-percha and filling of canal irregularities and accessory canals. Disadvantages include the risk of vertical root fracture because of compaction forces, as well as less length control than in lateral compaction, with the potential for extrusion of material into the periradicular tissues. Warm vertical compaction is difficult in curved canals where rigid pluggers are unable to penetrate to the necessary depth, requiring that the canals be enlarged and more tapered in comparison with the lateral condensation technique. This excessive removal of tooth structure weakens the root.

**Temperature control**

The DownPak Cordless obturation device (EI, a Hu-Friedy Company, Chicago, IL), as well as the System B, and Touch ‘n Heat (SybronEndo) devices, are alternatives to applying heat with a flame-heated instrument because they permit temperature control. (Figure 8)

The critical level of root-surface heat required to produce irreversible bone damage is believed to be greater than 10°C. However, the use of a flame-heated instrument does not permit temperature control. In one study comparing root-surface temperatures 2 mm below the CEJ for warm vertical obturation using the System B heat source, the Touch ‘n Heat device, and a flame-heated carrier in maxillary and mandibular incisors and premolars, only the System B produced temperature increases of less than
10°C for mandibular incisors, suggesting that caution should be exercised with the Touch ‘n Heat temperature setting and with flame-heated carriers. A second study, however, found that using the System B device resulted in more voids in the gutta-percha root filling than using the Touch ‘n Heat device.

The Endotec II (Medidenta International Inc; Woodside, NY), is a battery-powered, heat-controlled spreader/plugger. The quick-change, heated tips are sized equivalent to a No. 30 instrument, are autoclavable, and can be adjusted to any access angulation. However, the device requires specific positioning to allow activation of the instrument using the small, round button on one side of the device. (Figure 9)

Figure 9. Endotec II

Investigators have demonstrated that the Endotec II produced a fusion of the gutta-percha into a solid homogeneous mass, and have found that warm lateral compaction with the Endotec II increased the weight of the gutta-percha mass by 14.63 percent when compared with traditional cold lateral compaction. This device’s technique requires cleaning and shaping of canals with a continuous taper design and an apical stop. After the primary point is fitted to the working length, the hand spreader and the Endotec II’s plugger/spreader are fitted, and silicone stops are placed to mark the canal length. A small amount of sealer is applied. The master point is then firmly positioned and gently adapted with a hand or finger spreader. It has been recommended that one or two additional gutta-percha points be placed to reduce the possibility that the warm plugger will loosen the point when the tip is retracted. The device is activated and, using light pressure, the tip is inserted beside the master cone to within 2 to 4 mm of working length. The tip is rotated for 5 to 8 seconds and removed cold. An unheated spreader can be placed in the resulting channel to ensure adaptation, followed by an accessory cone. The process is continued until the canal is totally filled.

The Continuous Wave Compaction Technique is a variation of warm vertical compaction. It employs the System B unit and tapered, stainless-steel pluggers—each with a tip diameter of 0.5 mm. The gutta-percha cones mimic the tapered preparation, permitting application of greater hydraulic force during compaction with appropriately tapered pluggers. After fitting the master cone, a plugger is sized to fit within 5 to 7 mm of the canal length. (Figure 10) The point of plugger binding should be noted, as once the instrument reaches this point, the hydraulic forces on the gutta-percha will decrease and forces on the root increase. There appears to be a correlation between the depth of the heated plugger being at the working length, and the quality of obturation.

The System B unit is set to 200°C in touch mode. The plugger is inserted into the canal orifice and activated to remove the excess coronal material. Compaction is initiated by placing the cold plugger against the gutta-percha in the canal orifice. Firm pressure is applied, along with heat. The plugger is moved rapidly (for 1 to 2 seconds) to within 3 mm of the binding point. The heat is inactivated while firm pressure is being maintained on the plugger for 5 to 10 seconds. After the gutta-percha has cooled, a 1-second application of heat separates the plugger, and it is removed. In ovoid canals where the canal configuration may prevent the generation of hydraulic forces, an accessory cone can be placed alongside the master cone before compaction. (Figure 11) With type II canals, the master cones are placed in both canals before compaction. A hand plugger is used to stabilize the cone in one canal, while the other is obturated. Filling the remaining space left by the plugger can be accomplished with a thermoplastic-injection technique or by fitting an accessory cone into the space with sealer, heating it, and compacting it with short applications of heat and vertical pressure. (Figure 11)
The DownPak — 3D Obturation with heat and vibration

The DownPak is an innovative device recently introduced to the U.S. market that allows three-dimensional obturation with heat and vibration. Used in Europe under the name EndoTwin, it recently gained Food and Drug Administration clearance in the United States. The DownPak is cordless and designed with a multifunctional, endodontic heating and vibrating spreader device, and can be used for both warm vertical and lateral condensation techniques. It is suitable for use with gutta-percha, Resilon, and current hybrid resin filling materials. The clinician can choose to work with or without tip vibration or condensation techniques, making this device versatile. (Figure 12)

The DownPak technique involves adapting a master cone in the same manner as with lateral compaction. A 0.04 taper gutta-percha cone is fitted in the root canal to working length. The 0.02 taper spreader of the battery-powered DownPak is activated and heated for 2 seconds in vibration mode and placed between the master cone and the dentin. It is advanced until the tip reaches within 2 mm of working length. The spreader is removed and a D11T spreader is placed to within 1 mm of the working length in order to condense the filling material. A fine-medium (FM) accessory gutta-percha point is then placed. This procedure is repeated until no more than 2 mm of the spreader can be advanced into the canal. Traces of gutta-percha and sealer are removed from the chamber with alcohol.

DownPak offers a wide selection of tips in nickel-titanium and Ultrasoft stainless steel. The heat-carrying tips have been designed with geometries that are consistent with tapered root canal preparations. (Figure 13) The XF tip with ISO 0.030 diameter and 0.02 taper allows for deeper condensation, especially in narrow canals. The system also offers two tips for cautery or the removal of plastic obturator handles. In addition, the pluggers are extremely flexible for obturating curved canals (thereby avoiding the need to enlarge the canals, associated with warm vertical condensation techniques and curved canals).

Vibration has been shown to increase gutta-percha fill density. (Figure 14) One study at the University of Missouri-Kansas City School of Dentistry showed that DownPak’s combination of heat and vibration resulted in a denser, more compact filling of the root canal space. That study concluded that the system, in heat and vibration mode, as well as the Elements Obturation System, resulted in better replication of the intracanal defects when compared to other techniques. An in vitro study by Wu et al. compared the use of the System B device in accordance with the manufacturer’s instructions, the DownPak with heat only, and the DownPak with heat and vibration. A significantly smaller percentage of gutta-percha-filled area was found after using the System B than was found after using the DownPak, either with heat and vibration or with heat only.
alone. Further, DownPak’s heat-and-vibration combination was more effective in filling the root canal areas than was the DownPak with only heat.\textsuperscript{59}

Pagavino et al. found in another in vitro study that the use of the DownPak device with heat and vibration, when compared to heat only, resulted in a greater percentage of gutta-percha-filled area at the 1.25-mm level from working length with either a 0.4 or 0.8 taper, and at the 2.5-mm level with a 0.4 taper in simulated curved canals.\textsuperscript{60} While vibration has a lower frequency than ultrasound (which has been found to be effective in cold lateral condensation), it has been found to enable incremental flow of the warm gutta-percha. The manufacturer claims better results in less time and reduced coronal and apical leakage. Additionally, it is claimed that the system works with all warm condensation techniques and may even benefit cold lateral techniques when using only the vibration feature.

**Plastic-Injection Techniques**

The **Obtura II** system consists of a hand-held “gun” with a chamber into which pellets of gutta-percha are loaded, along with silver needles of varying gauges used to deliver the thermoplasticized material to the canal. (Figure 15) The temperature, and thus the viscosity, of the gutta-percha can be adjusted. A study found that at 6 mm from the apex, the highest internal temperature of the Obtura II was 27°C.\textsuperscript{61} A hybrid technique is often employed by filling the canal to approximately 4 to 5 mm from the apex using the lateral compaction technique before gradually filling the coronal portion with thermoplasticized gutta-percha (Figure 16). The needle backs out of the canal as it is filled, and pluggers dipped in alcohol are used to compact the gutta-percha. Compaction should continue until the gutta-percha cools and solidifies to compensate for the contraction or shrinkage that occurs upon cooling. (Figure 17)

The **Calamus Flow Obturation Delivery System** (Dentsply-Tulsa Dental, Tulsa, OK) has a handpiece and activation cuff to enable control of the flow and temperature of the gutta-percha into the canal. (Figure 18) The activation cuff is released to stop the flow. The gutta-percha is packed in disposable, single-use cartridges, and a filling-material indicator lets you monitor the amount of remaining filling material. At this time, there is no published data regarding this method.

The choice of gutta-percha cannula depends on the desired consistency and whether or not the gutta-percha will be condensed. After removing the cannula from the heater, the needle should be placed on the hot part of the heater for several seconds. The temperature of the thermoplasticized gutta-percha as it is extruded through the needle tip ranges from 38°C to 44°C. The gutta-percha remains able to flow for 45 to 60 seconds, depending on the viscosity. Research supports the safe and effective use of Ultrafil.\textsuperscript{62,63}
**GuttaFlow** is a cold, flowable technique that combines polydimethylsiloxane sealer, powdered gutta-percha with a particle size of less than 30 μm, and nanosilver particles contained in a plastic capsule that is triturated prior to use. The apical preparation should be as small as possible to prevent extrusion, and the canal filled combined with a master point of gutta-percha. (Figure 21) The viscosity diminishes under pressure, enabling flow into the smallest canals. GuttaFlow can be applied directly into the canal with a file, or coated onto the master point.

The **Elements Obturation Unit** (SybronEndo) contains a System B device and a gutta-percha extruder in a motorized handpiece. (Figure 19) The extruder tips are sized 20-, 23-, and 25-gauge and are pre-bent. The disposable cartridges of gutta-percha are heated quickly and the unit shuts off automatically to prevent overheating of the material.

The **Ultrafil 3D System** (Hygienic-Coltene-Whaledent, Akron, OH) is a low-heat (70°C) system with a sterilizable injection syringe, three different types of disposable gutta-percha cannulae with attached needles that can be pre-curved, and a portable heating unit. (Figure 20)

It sets regardless of moisture or temperature and has very low solubility. The material expands slightly (0.2 percent), resulting in an excellent seal of the root canal.64,65,66 GuttaFlow with a single gutta-percha master cone creates an apical seal that is equivalent to the seal produced with gutta-percha/AH Plus sealer, using warm vertical compaction.67 (Figures 22, 23) GuttaFlow should not be used with deciduous teeth as it is not resorbed.

Regardless of the technique, any plastic injection system has the potential for significant overfilling of the canal and the clinician needs to be attentive to length control of the canal obturating material.

**Carrier-Based Gutta-Percha**

**Thermafil** (Dentsply-Tulsa Dental, Tulsa, OK) consists of a plastic core coated with alpha phase gutta-percha and a heating device that controls the temperature. (Figure 24)
The carrier is set to the predetermined length using the millimeter calibration markings on the carrier shaft. After heating it, the clinician has approximately 10 seconds to retrieve and insert it into the canal, without rotating or twisting it. A rapid insertion rate has been shown to enhance obturation. The position of the carrier is verified radiographically. The gutta-percha is allowed 2 to 4 minutes to cool before resecting the carrier. (Figure 25) An advantage to this technique is the movement of gutta-percha into lateral and accessory canals; however, extrusion of material beyond the apical extent of the preparation is a disadvantage.

**Successfil** (Hygienic-Coltene-Whaledent, Inc., Akron, OH) uses gutta-percha in a syringe. Carriers (titanium or radiopaque plastic) are inserted into the syringe to the measured length of the canal. The gutta-percha is expressed on the carrier, with the amount and shape determined by the rate of withdrawal from the syringe. The carrier with the gutta-percha is placed in the canal to the prepared length. The gutta-percha can be compacted around the carrier with various pluggers, depending on the canal morphology. This is followed by the severing of the carrier slightly above the orifice using a bur.

**SimpliFill** (Discus Dental, Culver City, CA) is employed following canal preparation using Lightspeed instruments. The carrier has an apical plug attached with 5 mm of gutta-percha, which can be modified if the plug is too small by clipping the end in 1-mm increments to obtain an appropriate fit. A carrier consistent with the master apical rotary file is fitted to within 1 to 3 mm of the prepared length. The carrier is slowly advanced to the prepared length, which may require firm pressure. (Figure 26) With the plug at the corrected working length, the handle is quickly rotated counter-clockwise a minimum of four complete turns. The coronal space can then be filled with gutta-percha. This sectional technique is efficient, and leakage potential is similar to other methods of obturating canals.

**Thermomechanical Compaction**
This method utilizes a compactor with flutes similar to a Hedstrom file, but with the flutes reversed. The compactor is selected based on the size of the canal preparation and inserted with the hand piece activated alongside the gutta-percha cone 3 to 4 mm from the prepared length. The gutta-percha is heated by the friction of the rotating bur, and is compacted apically and laterally as the device is slowly withdrawn from the canal. (Figure 27)

The main advantages include simplicity, speed, and the ability to fill canal irregularities. Disadvantages are extrusion of filling material beyond the apex, the potential for instrument fracture, difficulty in using the technique in curved canals, and uncontrolled heat generation.
The dental profession’s most important goal is to maintain the health and integrity of patients’ dentitions. Dental clinicians must recognize that a particular method of obturation will not satisfy every single case that requires endodontic therapy. The obturation method selected, whether a traditional method or a more contemporary one, must be consistent with the principles of clinical practice, i.e., to provide the best treatment for patients. A seal of the root canal system is desirable, but contemporary materials and methods available for obturation do not always achieve this physical and biological goal. The advent of new devices and techniques, such as those that utilize heat and vibration for warm lateral and warm vertical condensation, are revolutionizing the practice of endodontics and making obturation procedures more predictable.

### References


### Summary

The dental profession’s most important goal is to maintain the health and integrity of patients’ dentitions. Dental clinicians must recognize that a particular method of obturation will not satisfy every single case that requires endodontic therapy. The obturation method selected, whether a traditional method or a more contemporary one, must be consistent with the principles of clinical practice, i.e., to provide the best treatment for patients. A seal of the root canal system is desirable, but contemporary materials and methods available for obturation do not always achieve this physical and biological goal. The advent of new devices and techniques, such as those that utilize heat and vibration for warm lateral and warm vertical condensation, are revolutionizing the practice of endodontics and making obturation procedures more predictable.

### Table 4. Comparison of Techniques

<table>
<thead>
<tr>
<th>Method</th>
<th>Heat</th>
<th>Vibration</th>
<th>Lateral Condensation</th>
<th>Vertical Condensation</th>
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<tr>
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<tr>
<td>System B</td>
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The cones can be bent up to 180° without showing any signs or symptoms of delamination of the coating, and are matched in size to the preparations created by the files. Matching of the primary cone to the preparation is very important with any single cone technique, because the accurate fit of the cone to the preparation minimizes the amount of sealer used, as well as minimizing any potential shrinkage.
Questions

1. Root canal treatment can be predictably successful with _______________.
   a. careful cleaning and shaping of the canal(s)
   b. three-dimensional obturation
   c. a well-fitting coronal restoration
   d. All of the above

2. Silver cones were introduced in 1941, and were found to _______________.
   a. be excellent
   b. corrode
   c. fill irregularly shaped root canal systems
   d. be a great complement for gutta-percha points

3. Root canal sealer is _______________.
   a. to seal the space between the dentinal wall and the obturating core interface
   b. provide a hermetic seal
   c. for all techniques
   d. a and c

4. _______________ outlined the requirements for an ideal root canal filling material.
   a. Black
   b. Goodman
   c. Grossman
   d. None of the above

5. For many years, the material of choice for root canal filling has been gutta-percha without using any root canal sealer.
   a. True
   b. False

6. Alpha phase gutta-percha is _______________.
   a. non-flowable
   b. pliable
   c. able to flow when pressure is applied
   d. b and c

7. Gutta-percha cones are available in _______________ sizes.
   a. conventional
   b. standardized
   c. radiculated
   d. a and b

8. _______________ is used as an apical barrier prior to obturation.
   a. Biogel
   b. Mineral trioxide aggregate
   c. Mineral trioxide conglomerate
   d. None of the above

9. The basic obturation technique is _______________.
   a. lateral condensation
   b. horizontal compaction
   c. warm vertical condensation
   d. a and b

10. Lateral condensation offers _______________.
    a. excellent length control and no radiographs are required
    b. excellent length control and radiographs are required
    c. the clinician a way to obturate canals without using sealer
    d. b and c

11. There appears to be a correlation between spreader penetration and the establishment of a seal.
    a. True
    b. False

12. Root fracture can occur with cold lateral condensation with as little as _______________.
    a. 1 lb of pressure
    b. 1 kg of pressure
    c. 1.5 kg of pressure
    d. All of the above

13. Ultrasonic condensation was found in one study to _______________.
    a. produce adequate obturation
    b. have no benefit
    c. have a 93 percent success rate
    d. a and c

14. Vertical condensation forms the basis for the master-cone sectional, warm gutta-percha and thermoplasticized techniques.
    a. True
    b. False

15. Warm vertical condensation has been found to fill a higher percentage of the canal area with gutta-percha than the cold lateral condensation technique.
    a. True
    b. False

16. The warm vertical condensation technique offers _______________.
    a. movement of plasticized gutta-percha
    b. the ability to fill canal irregularities
    c. the ability to fill accessory canals
    d. All of the above

17. A heat-flamed instrument used for warm vertical condensation _______________.
    a. permits temperature control
    b. can result in excessive temperatures at the root surface that could result in bone damage
    c. is the most advanced technology available
    d. All of the above

18. Temperature control during warm condensation techniques can be achieved using the _______________ device.
    a. DownPak
    b. System B
    c. Endotec II
    d. All of the above

19. The continuous wave compaction technique involves _______________ to achieve obturation.
    a. the use of heated pluggers
    b. the generation of hydraulic pressure
    c. compaction
    d. All of the above

20. The DownPak device involves the use of _______________ to achieve obturation of the root canal(s).
    a. heat
    b. heat and vibration
    c. heat and ultrasonics
    d. All of the above

21. The DownPak device _______________.
    a. can be used for lateral condensation
    b. can be used for vertical condensation
    c. can be used with gutta-percha, GuttaFlow and Resilon
    d. All of the above

22. Vibration during condensation has been shown to _______________.
    a. increase gutta-percha density
    b. result in a greater percentage of gutta-percha-filled areas when used with heat, compared to the use of heat alone
    c. enable incremental flow of the gutta-percha
d. All of the above

23. _______________ can be used in a plastic injection technique.
    a. The Obtura II
    b. The System B
    c. MTA
d. None of the above

24. Plastic injection techniques have the potential for significant overfilling of the canal.
    a. True
    b. False

25. The carrier-based technique _______________.
    a. can enable movement of gutta-percha into lateral and accessory canals
    b. can be used with or without heat depending upon the specific product used
    c. utilizes silver points
    d. a and b

26. The thermomechanical compaction technique _______________.
    a. is simple and quick, and can fill canal irregularities
    b. is difficult to use in curved canals
    c. can result in uncontrolled heat generation
    d. All of the above

27. GuttaFlow is a _______________.
    a. cold flowable technique
    b. can be used with the DownPak technique
    c. carrier-based system
    d. a and b

28. The use of flexible pluggers while obturating curved canals _______________.
    a. carries the same risks as using rigid pluggers
    b. enables better access in the curved canals
    c. reduce the need to remove more tooth structure, weakening the tooth
    d. All of the above

29. Gutta-percha can be sterilized before use by _______________.
    a. placing the cones in an ultrasonic device for a brief period
    b. placing the cones in 5.25% NaOCl for 1 minute
    c. placing the cones in 2% NaOCl for 30 seconds
    d. All of the above

30. Gutta-percha can be made to flow using _______________.
    a. heat
    b. vibration
    c. solvents
    d. All of the above
Educational Objectives

1. Understand the requirements for successful obturation of root canals.
2. Be knowledgeable concerning available root canal obturating materials and what constitutes an ideal root canal filling material.
3. Understand the basic techniques and their steps for root canal obturation.
4. Be knowledgeable about the types of devices available for the application of heat and/or vibration during root canal obturation and the rationale for their use.

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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