

Bioactive endodontic obturation: Combining the new with the tried and true

MTA Fillapex and Continuous Wave of Condensation

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Fig. 1a A post-treatment image of a maxillary first molar, which illustrates the complex anatomy that exists in the apical one-third of the palatal root. (Images courtesy of Dr Gary Glassman, unless otherwise noted)



Fig. 1b A post-treatment film of a mandibular first molar demonstrates the importance of shaping canals and cleaning and filling root-canal systems. (Image courtesy of Dr Clifford J. Ruddle, Santa Barbara, CA, USA)



The triad of biomechanical preparation, chemotherapeutic sterilization and three-dimensional obturation is the hallmark of endodontic success.^{1,2}

toward shaping canals and cleaning root-canal systems.²⁻⁴

Fig. 2 Microcomputed tomography 3-D reconstruction of the mesial root-canal of mandibular molar; the presence of an isthmus between the root-canals and multiple foramina are evident. These areas must be cleaned of their organic debris and bacterial contaminants by thorough irrigation protocols in preparation of being three-dimensionally sealed with thermo-softened gutta-percha. (Image courtesy of Dr Ronald Ordinola Zapata, Brazil)

The obturation of root-canal systems represents the culmination and successful fulfillment of a series of highly integrated procedural steps (Figs. 1a & b). Although the excitement associated with capturing complicated root-canal anatomy is understandable, scientific evidence should support this enthusiasm. Moving heat-softened obturation materials into all aspects of the anatomy is dependent on eliminating pulpal tissue, the smear layer and related debris and bacteria and their by products, when present. To maximize obturation potential, clinicians would be wise to direct treatment efforts

Shaping facilitates three-dimensional cleaning by removing restrictive dentin, allowing a more effective volume of irrigant to penetrate, circulate and potentially clean into all aspects of the Root-canal system (Fig. 2). Well-shaped canals result in a tapered preparation that serves to control and limit the movement of warm gutta-percha during obturation procedures. Importantly, shaping also facilitates 3-D obturation by allowing pre-fit pluggers to work deep and unrestricted by dentinal walls and move thermo-softened obturation materials into all aspects of the root-canal system. Improvement in obturation potential is largely attributable to the extraordinary technological advancements in shaping canals and cleaning and filling root-canal systems.⁴⁻⁶



In the article "Filling Root-canals in Three Dimensions,"⁷ Dr Herb Schilder stated that while there was merit in all obturation techniques available at that time, "when used well... vertical condensation of warm gutta-percha produces consistently dense, dimensionally stable, three-dimensional root-canal fillings." This landmark article gave birth to a paradigm shift in not only a variety of warm gutta-percha techniques, but in a new approach to cleaning and shaping canals, as well as irrigation protocols.⁸

In addition to the classic "Schilder technique" of obturation, there is Steve Buchanan's "Continuous Wave of Condensation" technique⁹ and variations thereof. Vertical condensation of gutta-percha is now one of the most-trusted obturation methods of our time. It is taught in most of the graduate endodontic programs in North America and in a growing number of undergrad programs as well. Its success rate is well documented.^{8,10}

This article will feature the Elements Obturation Unit (Axis | SybronEndo, USA) that may be used to fill root-canals systems (Fig. 3a) using the Continuous Wave of Condensation technique and a new mineral trioxide aggregate-based endodontic sealer that is biocompatible and bioactive, called MTA Fillapex (MTA-F; Angelus, Londrina, Brazil) (Fig. 3b). Mineral trioxide aggregate was developed at Loma Linda university and in 1998 received approval from the FDA for human use.^{11,12}

Since then, MTA has shown excellent biological properties in several *in vivo* and *in vitro* studies.¹³⁻¹⁸

In cell culture systems, for example, MTA has been shown to enhance proliferation of periodontal ligament fibroblasts,¹⁵ to induce differentiation of osteoblasts^{16,17} and to stimulate mineralization of dental pulp.

In an effort to expand its applicability in endodontics, MTA-based root-canal sealers have been proposed, such as MTA Fillapex.¹⁹⁻²²

MTA Fillapex is an endodontic sealer that combines the proven advantage of MTA with a superior canal obturation product. Its formulation in the paste/paste system allows a complete filling of the entire root-canal, including accessory and lateral canals. MTA, present in the composition of MTA Fillapex, is more stable than calcium hydroxide, providing constant release of calcium ions for the tissues and maintaining a pH



Fig. 3a

Fig. 3a_ The Elements Obturation Unit replaces multiple devices while taking up approximately one-third the space of separate machines. The left side of the unit incorporates the controls and handpiece from System-B, while the right side incorporates the extruder system and its controls.

that elicits antibacterial effects. The tissue recovery and the lack of inflammatory response are optimized by the use of MTA and disalicylate resin. The product is eugenol-free and will not interfere with adhesive procedures inside the root-canal.

The two-paste system contains tricalcium silicate, dicalcium silicate, calcium oxide and tricalcium aluminate, a salicylate resin, a natural resin and bismuth oxide as a radiopacifying agent. The combination of these components has been shown to have bioactive potential in its ability to stimulate nucleation sites for the formation of apatite crystals in human osteoblast-like cell culture.²²

The two pastes of MTA Fillapex are mixed in equal volumes and dispensed on a glass slab. Its average working time is 35 minutes, with an average setting time of 130 minutes.

The chemical reaction that promotes setting in MTA Fillapex is not a polymerization reaction between pastes but a com-



Fig. 3b

Fig. 3b_ MTA Fillapex is available as a two-paste system, which must be mixed into a homogeneous consistency, or as a double syringe with self-mixing tips.

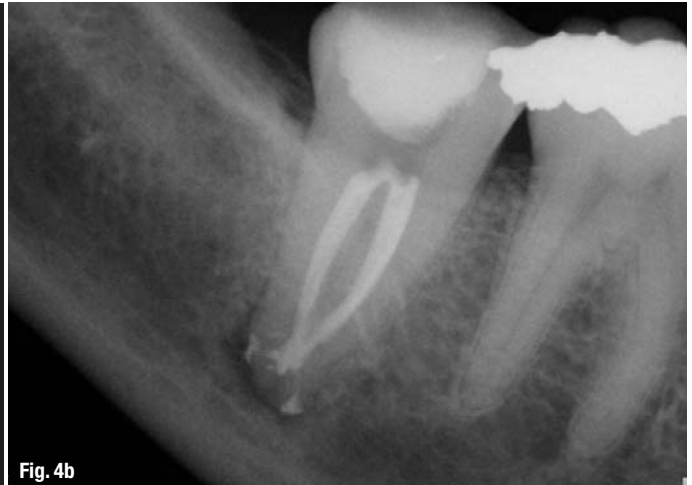


Fig. 4a

Fig. 4b

Figs. 4a & b Gutta-percha and sealer can move into extremely small canal ramifications by virtue of the vertical and lateral forces created during the simultaneous warming and condensation of the gutta-percha.

plexation reaction. The complexation reaction is an autocatalytic process. A chain reaction is initiated by water molecules in the external medium that has an intrinsic process of self-acceleration. The complexation reaction is also a chelation reaction where $\text{Ca}(\text{OH})_2$ contacts the disalicylate resin, resulting in the entrapment of calcium ions in the compound. In addition to salicylate, $\text{Ca}(\text{OH})_2$ is fundamental. The major source of $\text{Ca}(\text{OH})_2$ responsible for the MTA Fillapex reaction is from the hydration of free CaO , which is in high concentration in the formula. It is therefore concluded that the moisture present in the dentin tubules hydrates free CaO , forming $\text{Ca}(\text{OH})_2$, which will react with the salicylate and promote the setting.²³

The Continuous Wave of Condensation technique

This technique allows a single-tapered electric heat plugger to capture a wave of condensation at the orifice of a canal and ride it, without release, to the apical extent of down packing in a single, continuous movement. Because the tip moves through a viscosity-controlled material into a tapered-like canal form, the velocity of the thermo-softened gutta-percha and sealer moving into the root-canal system actually accelerates as the downpacking progresses, moving softened gutta-percha into extremely small ramifications (Figs. 4a, b).

The continuously tapered root-canal preparation facilitates the fit of a suitably sized gutta-percha cone, preferably fine-medium or medium. A clever tool to assist with the cone fit, especially if you choose not to use pre-sized cones or prefer nonstandardized

cones, is a gutta-percha gauge such as the Tip Snip (Axis | SybronEndo, USA) (Fig. 5). This allows you to customize a non-standardized or tapered cone to a precise apical diameter. The master cone is fit in a fluid-filled canal to more closely simulate the lubrication effect that sealer will provide when sliding the buttered master cone into the prepared canal.

Further, the master cones should be able to be inserted to the full working length and exhibit apical tugback upon removal. It is simple to fit a master cone into a patent, smoothly tapered and well-prepared canal.⁴

The intimacy of diametrical fit between the cone and the canal space is confirmed radiographically (Fig. 6). The cone is then trimmed about 0.5 to 1 mm from radiographic terminus, so that its most apical end is just short of the working length to accommodate vertical movement of the vertically condensed gutta-percha cone.

The System-B 0.06 or 0.08 taper, 0.5 mm plugger should fit to within 4 to 6 mm from most canal termini and is pre-fit to its binding point in the canal, and the rubber stop is adjusted adjacent to a reference point (Fig. 7).

Difficulties in achieving adequate plugger depth are because of deficient deep shape in the canal preparation (inadequate enlargement 3 to 4 mm shy of the terminus).

Stainless-steel Buchanan pluggers (Axis | SybronEndo, USA) are pre-fit into the canals to their binding point. Rubber stoppers are adjusted on these pluggers to the occlusal reference point, corresponding to 2 mm short of the apical binding point. These pluggers are placed aside to be used later in the backfill phase of canal obturation (Fig. 8).



Fig. 5

Fig. 5_ The Tip Snip can be used to customize the apical size of the master gutta-percha cone.

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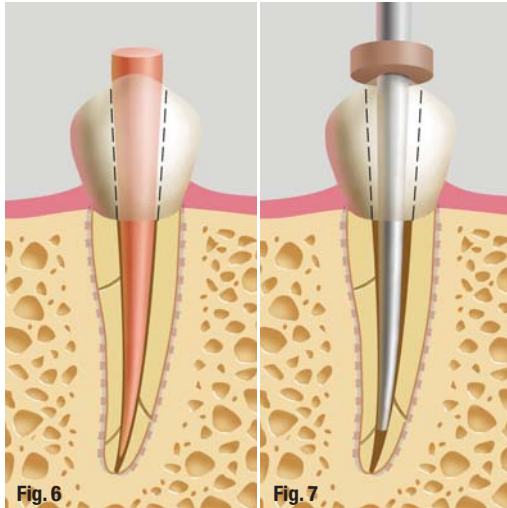
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Fig. 6 A non-standardized (fine/medium or medium) gutta-percha cone is fit into the tapered root-canal preparation, making sure that "apical tugback" has been achieved 0.5 to 1 mm short of the working length (distance from apical reference point will vary with canal curvature and size).

Fig. 7 It is essential that appropriate System-B plugger is pre-fit into each canal to its binding point. A rubber stop must be placed and adjusted to the appropriate coronal reference point for each canal.



Sealer and master cone placement

MTA Fillapex can be used for the warm gutta-percha with vertical condensation technique and affords several advantages.²³

The presence of MTA in the formula along with its calcium ion release allows the formation of new tissue, including root cementum without causing an inflammatory reaction. Perfect radiographic visualization is possible because of its high radiopacity, and its excellent flow properties make MTA Fillapex suitable to penetrate and fill lateral and accessory canals. Upon setting, MTA Fillapex expands, thereby providing an excellent seal of the root-canal, avoiding the penetration of tissue fluids and/or bacterial recontamination. It is available in a two-paste system, which

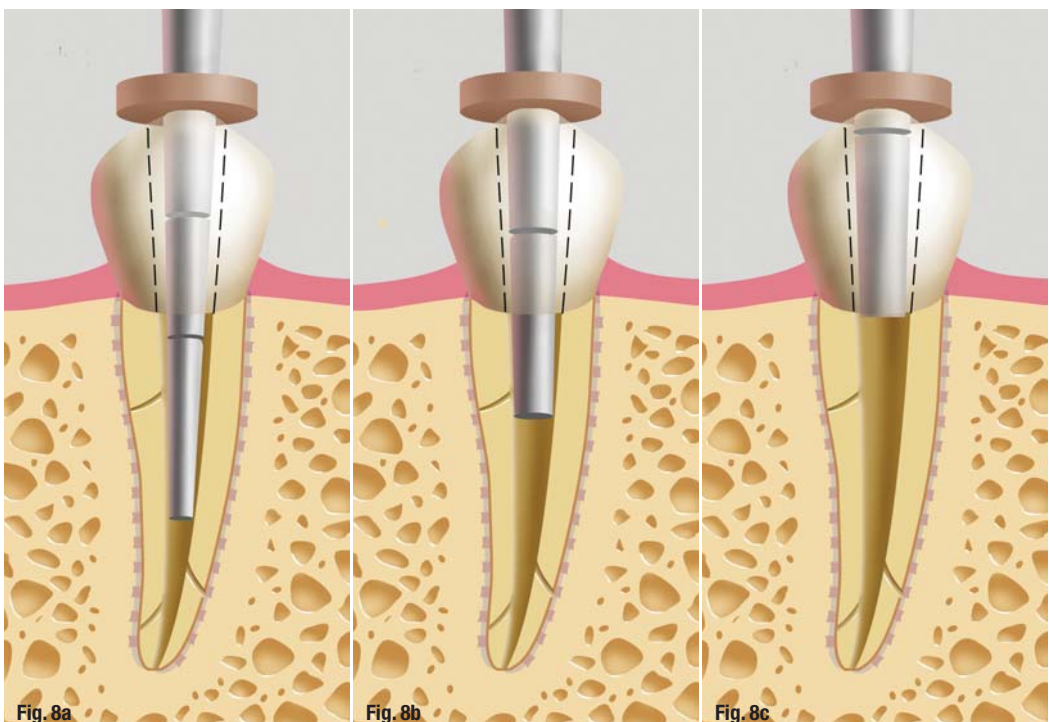
allows easy handling, insertion and adequate working time to be used by both specialists and/or general practitioners. If retreatment is necessary it is easily removed particularly when used with GP points.

The amount of sealer used in this obturation technique should be minimal.

The radicular portion of the master cone is lightly buttered with sealer and gently swirled as it is slowly slid to length. Placing the master cone in this manner will serve to more evenly distribute sealer along the walls of the preparation and, importantly, allow surplus sealer to harmlessly vent coronally. To be confident that there is sufficient sealer, the master cone is removed and its radicular surfaces inspected to ensure it is evenly coated with sealer. If the master cone is devoid of sealer, then simply re-butter and re-insert this cone to ensure there is sufficient sealer present. When the master cone is evenly coated with sealer and fully seated, obturation can commence.⁴ The canal is dried and the master cone is cemented in the canal with sealer (Fig. 9).

The System-B handpiece is activated by depressing the button with a gloved finger. The tip will heat instantly, and the LED indicator on the handpiece will illuminate. The tip will remain heated only as long as the button is depressed. A "time-out" feature assists the clinician by shutting off the energy to the tip after four seconds. This will aid in avoiding overheating of the tooth and/or tissue. The handpiece will need to be reactivated to resume heating beyond the preset duration.

Figs. 8a-c Buchanan pluggers may be pre-fit into the canals to their binding point. Rubber stoppers are adjusted on these pluggers to the occlusal reference point corresponding to 2 mm short of the apical binding point.



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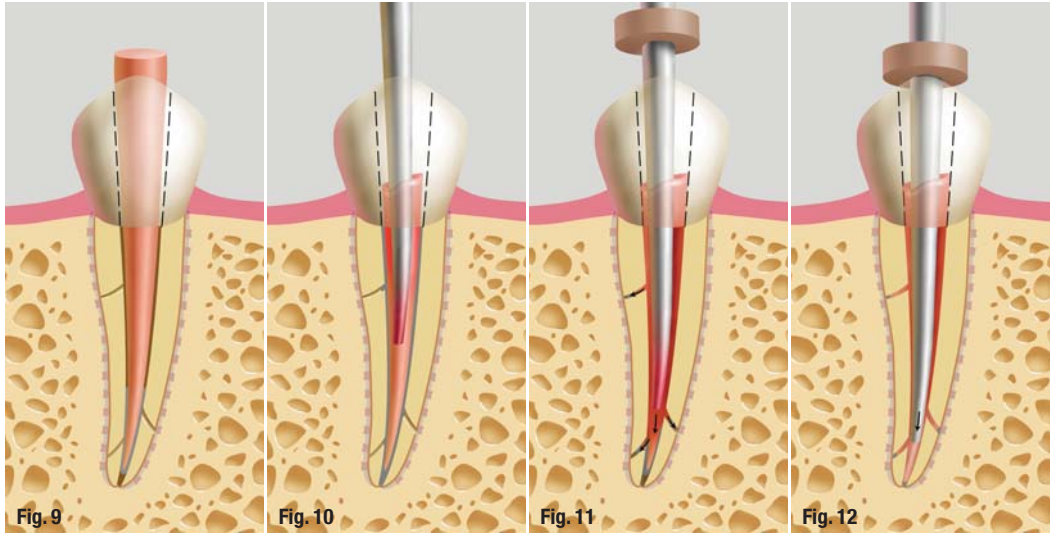
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Fig. 9_ The master cone is cemented in the canal with sealer.

Figs. 10 & 11_ With the activation button depressed on the System-B handpiece, the pre-fit, preheated plugger is smoothly driven through the mass of gutta-percha to within 4 to 6 mm of the binding point.

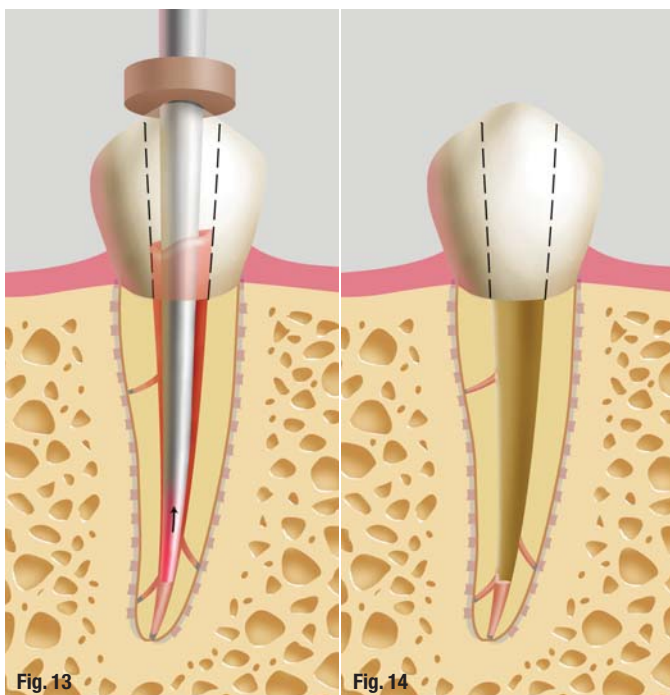
Fig. 12_ The activation button should be released once within 3 to 4 mm of the apical binding point. The plugger should slow and stop within 2 mm short of the binding point. Apical pressure is maintained for a full 10-second 'sustained' push to prevent the cooling gutta-percha mass from shrinking.



Figs. 13 & 14_ The System-B activation button is depressed for one second then released. The plugger is held in position for one second after the button is released, and the plugger is removed with the down pack surplus of gutta-percha, leaving the apical seal intact. All portals of exit may be sealed, primarily with gutta-percha or a combination of gutta-percha and sealer, and the canal is ready for backfilling

The master cone is seared at the orifice of the canals with the activated System-B plugger and then gently "seated" with a larger stainless-steel Buchanan plugger. The plugger is driven through the center of the gutta-percha in a single motion (about one to two seconds), to a point about 3 to 4 mm shy of its apical binding point (Figs. 10 & 11).

While maintaining pressure on the plugger, the activation button on the System-B is released and the plugger slows its apical movement as the plugger tip cools (about one second) to within 2 mm from its apical binding point. After the plugger stops short of its binding point, apical pressure on the plugger is sustained until the apical mass of gutta-percha has set (5 to 10 seconds), to prevent any shrinkage that occurs upon cooling (Fig. 12).



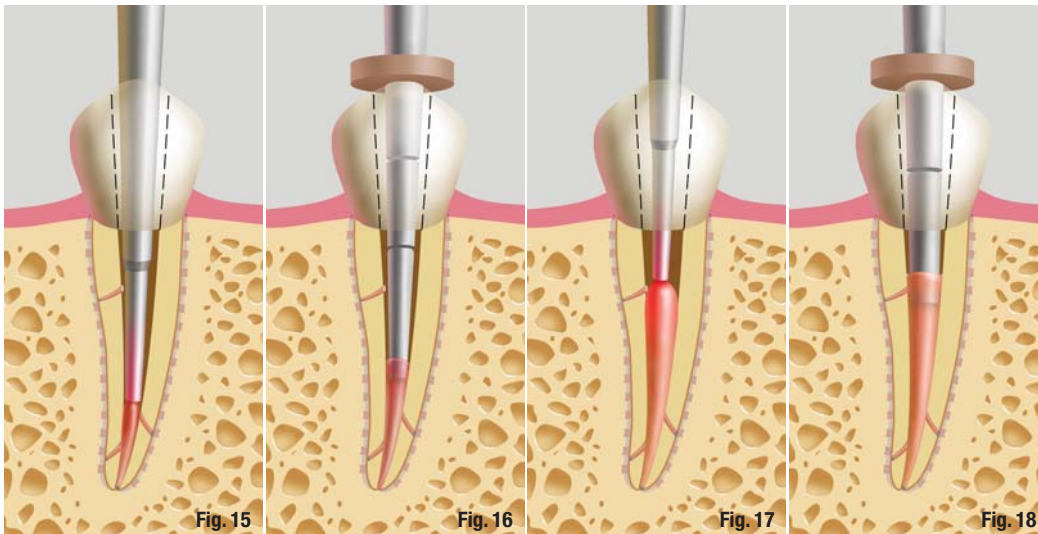
_Separation burst

After the apical mass has set, the activation button on the System-B is depressed again, for a one-second surge of heat. Pause for one second after this separation burst, and then remove the heated plugger and the middle and coronal gutta-percha, leaving behind the 4 to 6 mm apical plug of gutta-percha (Figs. 13 & 14). Because these pluggers heat from their tips, this separation burst of heat allows for quick, sure severance of the plugger from the already condensed and set apical mass of gutta-percha, minimizing the possibility of pulling the master cone out. Be certain to limit the length of this heat burst, as the goal is separation from the apical mass of gutta-percha without reheating.

Clinicians must be very alert during the first second of the downpack that the binding point is not reached before completion of the downpack. If heat is held for too long, the plugger drops to its binding point in the canal and then cannot maintain condensation pressure on the apical mass of gutta-percha during cooling, possibly allowing it to pull away from the canal walls. If binding length is reached by mistake, the heat plugger should be removed immediately, and the small end of the nickel-titanium end of a Buchanan hand plugger (Sybron Endo, USA) should be used to condense the apical mass of gutta-percha until set.

_Backfilling

The Elements Obturation Unit (Fig. 3a) has an extruder handpiece that accommodates disposable pre-loaded cartridges of gutta-percha of varying densities and is use to back fill the root-canal space. They are available in easy-flow, normal-flow and heavy-body-flow viscosities. The applicator tips are available in 20-, 23- and 25-gauge diameters. There is enough gutta-percha in the disposable cartridges to fill an average four-canal molar. The author prefers to use



the heavy-body gutta-percha and a 23-gauge applicator tip, as they are suitable for most canals treated.

The applicator tip is placed into the root-canal space until it penetrates the coronal aspect of the apical plug of gutta-percha for five seconds to rethermo-soften its most coronal extent. This procedural nuance promotes cohesion between each injected segment of warm gutta-percha.⁴ Segments of 5 to 6 mm of gutta-percha are then deposited. Injecting or dispensing too much gutta-percha leads to shrinkage and/or voids that result in poorly obturated canals.⁴ As gutta-percha is extruded from the applicator tip, the viscosity gradient of the back pressure produced will push the tip coronally from the root-canal space.

The technique sensitivity requires that when this sensation occurs, the operator must sustain pressure on the trigger mechanism as the applicator tip moves from the canal. The Buchanan pluggers are then used in sequence to maximize the density and homogeneity of the compressed gutta-percha mass. This sequence of thermo-softened gutta-percha injection and progressive compaction is continued until the obturation of the entire root-canal space is achieved (Figs. 15-21).

Restoration of the endodontically treated tooth

To ensure a seamless link between the root-canal procedure and the permanent restoration of the tooth, immediate restoration is the very best policy to protect the hard work you have just accomplished with the previous steps. Where temporization is necessary, ensuring a coronal seal is crucial to long-term success. Taking a few minutes to lay down an effective coronal seal protects your three-dimensionally obturated root-canal from coronal leakage.⁸

The future

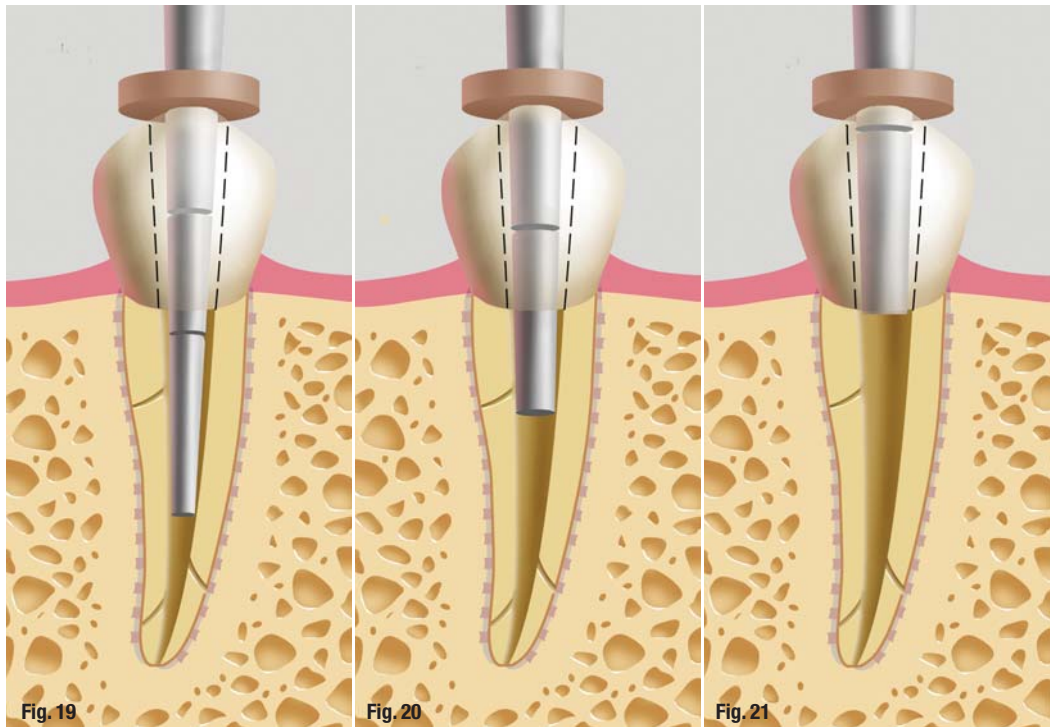
With each improvement and modification of the technical limitations of the technique, the thermo-softened millennium will continue to expand the horizons of endodontic success and elevate the standard of care and pursuit of excellence in clinical treatment materials.^{1,2}

As the health of the attachment apparatus associated with endodontically treated teeth becomes fully understood and completely appreciated, the naturally retained root will be recognized as the "ultimate dental implant." When properly performed, endodontic treatment is the cornerstone of restorative and reconstructive dentistry.³

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Figs. 15–21 Applicator tips for the EOU System are available in sizes #20, #23 and #25 gauges. Additional root-canal sealer may be placed in the coronal aspect of the root-canal with a hand file prior to back filling. Four to 6-mm increments of gutta-percha are injected into the canal space then immediately condensed with the pre-fitted Buchanan pluggers in sequence using the sequentially larger pluggers as the coronal aspect of the canal is approached. As thermosoftened gutta-percha is deposited in the canal, backpressure is produced and the applicator is forcibly extruded from the canal space. It is essential that the operator continue injecting as the applicator tip is retrieved from the canal in order to avoid inadvertent removal of the newly deposited gutta-percha mass prior to condensation.



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Gary D. Glassman, DDS, FRCD(C) graduated from the University of Toronto, Faculty of Dentistry in 1984 and was awarded the James B. Willmott Scholarship, the Mosby Scholarship and the George Hare Endodontic Scholarship for proficiency in Endodontics. A graduate of the Endodontology Program at Temple University in 1987, he received the Louis I. Grossman Study Club Award for academic and clinical proficiency in Endodontics. The author of numerous publications, Gary is on staff at the University of Toronto, Faculty of Dentistry in the graduate department of endodontics and Adjunct professor of dentistry and director of endodontic programming at UTech in Kingston, Jamaica. Dr Gary Glassman maintains a private practice in Toronto.

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