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FILLING ROOT CANAL SYSTEMS THE CALAMUS 3D OBTURATION TECHNIQUE

by Clifford J. Ruddle, DDS

Virtually all dentists are intrigued when endodontic post-treatment radiographs exhibit filled accessory canals. Filling root canal systems represents the culmination and successful fulfillment of a series of procedural steps that comprise start-to-finish endodontics ***(Figure 1)***. Although the excitement associated with the so-called "thrill-of-the-fill" 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 toward *shaping* canals and *cleaning* root canal systems.[1]

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 ***(Figure 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 3D obturation by allowing pre-fit pluggers to work deep and unrestricted by dentinal walls and move thermosoftened 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.[2,3]

This article will feature the new Calamus Dual 3D Obturation System *(Dentsply Tulsa Dental Specialties)* that may be used to fill root canal systems ***(Figure 3)***. Schilder described the classic *vertical condensation technique* more than forty years ago.[4] Over time, a few different, yet similar, warm gutta percha techniques have evolved. The purpose of this article is to describe the Calamus Dual 3D Obturation System and how to use this technology to perform the vertical condensation technique. The clinician is encouraged to read, visualize, and learn more about how to perform each and every procedural step that directly serves to influence filling root canal systems; this includes how to perform the other hybrid warm gutta percha techniques using the Calamus technology.[1,5]

VERTICAL CONDENSATION TECHNIQUE

The objective of the vertical condensation technique is to continuously and progressively carry a wave of warm gutta percha along the length of the master cone, starting coronally and ending in apical corkage ***(Figure 4)***. The physical and thermomolecular properties of gutta percha are well understood and have been clearly described in a series of groundbreaking articles published decades ago.[6-10] The content of these scientific articles provides insight, understanding, and reference for the clinical and technical description that follows. Although the author has previously described the verti-

Figure 1. A post-treatment film of a mandibular first molar demonstrates the importance of shaping canals and cleaning and filling root canal systems.

Figure 2. This animation supports the scientific evidence that shaped canals enhance the active exchange of irrigant into all aspects of the root canal system.

cal condensation technique,[11-12] this article represents the most recent advances in how to perform the warm gutta percha with vertical condensation technique.

CONE FIT AND PLUGGER SELECTION

Traditionally, a size medium *non-standardized* gutta percha master cone was selected and apically trimmed to fit snugly into the terminus of the prepared canal. The 6% taper of these master cones, as compared to the 2% taper of *standardized* gutta percha, ensured more effective hydraulics during obturation. Today, the selection of the correct master cone has been simplified because of the rediscovery of system-based endodontics. System-based master cones streamline treatment in that they are intended to have an apical diameter the same as and a rate of taper slightly less than the largest sized manual or mechanically driven file that was carried to the full working length.

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 cone should be able to be inserted to the full working length and exhibit *apical* tugback upon removal. This master cone can be apically trimmed and further customized with glass slabs or a spatula utilizing either cold or heat rolling techniques. It is simple to fit a master cone into a patent, smoothly tapered, and well-prepared canal.

Figure 3. *The Calamus Dual 3D Obturation System combines a "Pack" handpiece for downpacking with the "Flow" handpiece for backpacking.*

A diagnostic working film should confirm the desired position of the master cone and verify all the previous operative steps. The master cone is typically cut back about 1.0 mm from the *radiographic terminus* (RT) so that its most apical end is just short of the "apical constriction" or the actual position of the *physiologic terminus* (PT) ***(Figure 5)***. Specifically, the final length of any given prepared and finished canal is the reproducible distance from the reference point to the PT. Fortuitously, the position of the most apically instrumented foramen can be consistently located utilizing the paper point drying technique.[12]

Four manual pluggers, utilized to compact heat-softened gutta percha, provide working end diameters of 0.5 mm, 0.7 mm, 0.9 mm, and 1.3 mm *(Dentsply Tulsa Dental Specialties)*. Generally, a *larger* size plugger is selected that will work loosely, yet efficiently, over a range of a few millimeters in the coronal one-third of the canal. A *medium* size plugger is selected that will work passively and effectively over a range of a few millimeters in the middle one-third of the canal. In longer roots, a *smaller* size plugger may be required to work deeper and safely to within 5 mm of the canal terminus. Prefitting pluggers is essential and guarantees that when a plugger meets resistance, the plugger is on thermosoftened gutta percha and not binding against unyielding dentinal walls.

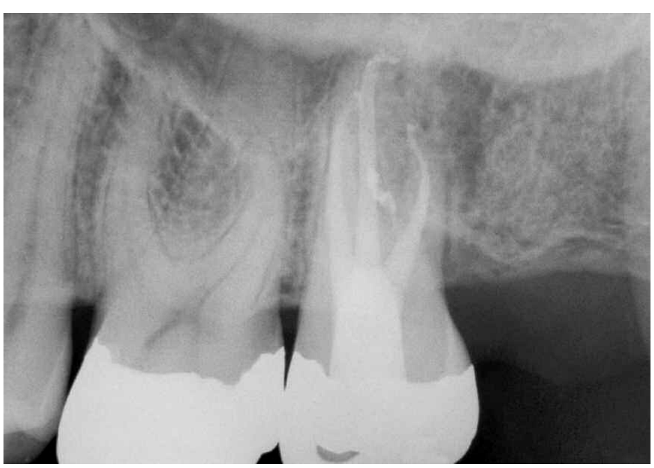

Figure 4. *A post-op film of a maxillary second molar. Note the abrupt apical curvature of the palatal system, recurvature of the DB system, and the filled furcal canal.*

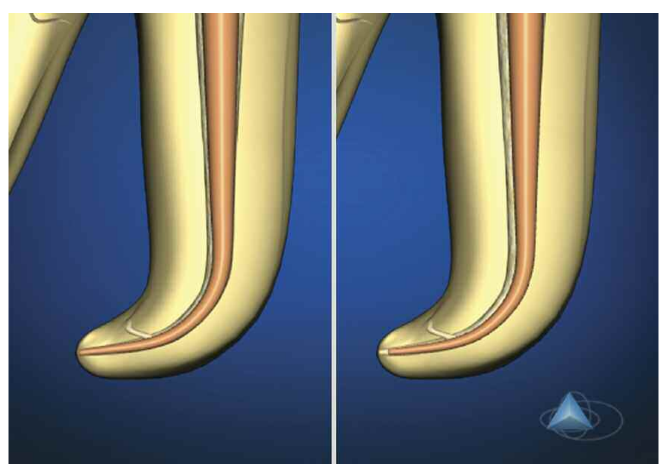

Figure 5. *These animations demonstrate the master cone fit to length and the master cone apically cut back based on the paper point drying technique.*

SEALER AND MASTER CONE PLACEMENT

Kerr Pulp Canal Sealer EWT (Extended Working Time) *(Henry Schein)* has been specifically formulated for the warm gutta percha with vertical condensation technique and affords several advantages.[13] These include:

1) Superior lubrication and flow
2) Adjustable viscosity
3) Dimensionally inert
4) Essentially non-resorbable
5) Sets in the presence of heat
6) Inhibits prostaglandins
7) Biocompatible

A fresh mix of Kerr Pulp Canal Sealer EWT completely sets extraorally within 30 minutes. Intraorally, this sealer sets even more rapidly, which advantageously serves to reduce an inflammatory post-obturation response directly related to a sealer puff or surplus material after filling. The amount of sealer used in this obturation technique should be minimal. Post-obturation histological sections demonstrate wall-to-wall gutta percha within the preparation and a thin 7-9 micron film of sealer occupying the dentin/gutta percha interface.[14] An ultrathin film of sealer is desirable and has been shown to be significantly less predisposed to washing out.[13] As an example, any single cone filling technique undesirably relies on "pools" of sealer to fill the space between the master cone and the dentin interface. It is illogical to assume that these cones, over their length, closely approximate the actual cross-sectional anatomy of any given canal following preparation. Regrettably, over time, the volume of the pools or lakes of cement are predisposed to shrink and dissolve, inviting microleakage and failure.[4,13]

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.

CALAMUS DUAL 3D OBTURATION SYSTEM

The Calamus Dual 3D Obturation System is one unit that conveniently combines both Calamus "Pack" and Calamus "Flow" handpieces ***(Figure 3)***. The Calamus Pack handpiece is the heat source that, in conjunction with an appropriately sized Electric Heat Plugger (EHP), is utilized to thermosoften, remove, and condense gutta percha during the downpacking phase of obturation. There are three variably sized EHPs and the one selected is based on the apical size, taper, and curvature of the finished preparation. The EHPs are available in ISO colors black, yellow, and blue, corresponding to working end diameters and tapers of 40/03, 50/05, and 60/06, respectively ***(Figure 6)***. The Calamus Pack handpiece also accepts a "thermal response tip" for conducting a diagnostic "hot test" on heat-sensitive pulps.

The Calamus Flow handpiece is utilized, in conjunction with a one-piece gutta percha cartridge and integrated canula, to dispense warm gutta percha into the preparation during the backpacking phase of obturation. The cartridges are single patient use and are available in 20 and 23 gauge sizes. The Calamus Dual 3D Obturation System provides a "bending tool" that may be utilized to place a smooth curvature on the canula. Ultimately, the gauge selected and the curvature placed should allow the canula to pass through the coronal two-thirds of the preparation and to contact the previously downpacked master cone. As an alternative to the Calamus Dual 3D Obturation System, the Calamus Pack and the Calamus Flow handpieces are available as standalone obturation devices.

Calamus Downpack

In preparation for initiating the downpack, the clinician should select the Calamus EHP that fits passively through the straightaway portion of the preparation and optimally to within 5 mm from the terminus of the canal ***(Figure 6)***. When the EHP cannot reach this desired level, in a well-shaped canal, the Calamus bending tool may be utilized to place a suitable curvature on the more apical portion of the 40/03 EHP that matches the curvature of the prepared canal. A silicone stop may be placed on the EHP to safely monitor its maximum depth of insertion. Because of the thermomolecular properties of gutta percha, the Calamus EHP will generate about a 5 mm heat wave through gutta percha, apical to its actual depth of placement. Following the placement of the sealer-buttered master cone in a canal with an irregular cross-section, it is beneficial to inject heat-softened gutta percha lateral to the master cone. This method will advantageously serve to initially thermosoften the master cone, maximize the volume of gutta percha, and effectively

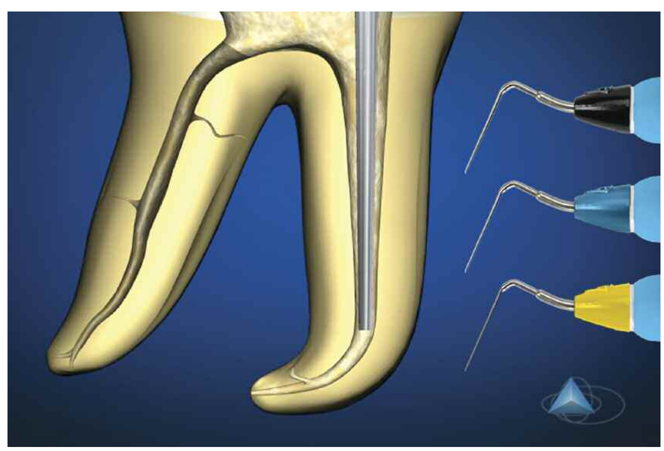

Figure 6. *Select the EHP that will loosely fit through the straightaway portion of the canal and optimally to within 5 mm from the full working length.*

increase hydraulics when commencing with the downpacking phase of obturation.

The Calamus EHP is activated and utilized to sear off the master cone at the CEJ in single rooted teeth or at the orifice level in multi-rooted teeth ***(Figure 7a)***. To capture the maximum cushion of warm rubber, the working end of the *large* size pre-fit plugger is methodically stepped around the circumference of the canal. This plugger is used with short, firm vertical strokes to scrape warm gutta percha off the canal walls and flatten the material coronally. The working end of the plugger is used to vertically press on this flattened platform of warm gutta percha for 5 seconds ***(Figure 7b)***. This action serves to automatically fill the root canal system, laterally and vertically, over a range of a few millimeters and is termed a *wave of condensation* (WOC).[4] Specifically, a WOC moves thermosoftened gutta percha into the narrowing cross-sectional diameters of the preparation, generates a piston effect on the entrapped sealer, and produces significant hydraulics. During this heating and compaction cycle, the operator will tactilely feel the warm mass of gutta percha begin to stiffen as it cools. Importantly, using a plugger to press on warm gutta percha during the cooling cycle has been shown to completely offset shrinkage.

To generate a progressively deeper heat wave along the length of the master cone, the Calamus EHP is activated and allowed to plunge 3 to 4 mm into the previously compacted material. Following the plunge, the EHP is deactivated and the operator should hesitate, a brief second, before removing the cooling instrument along with a "bite" of gutta percha ***(Figure 8a)***. Removing a bite of gutta percha results in the progressive apical transfer of heat another 4-5 mm along the length of the master cone and facilitates the placement of the *medium* size pre-fit plugger deeper into the root canal preparation. This plugger is used, as described above, to compact warm gutta percha into this region of the canal, producing a second wave of condensation ***(Figure 8b)***.

Depending on the length of the canal, only 2, 3, or 4 heating and removal cycles are required until the pre-selected EHP can be placed within 5 mm of the canal terminus ***(Figure 9a)***. Due to multiple heatings, thermal cycling progressively transfers heat into the apical one-third of the gutta percha

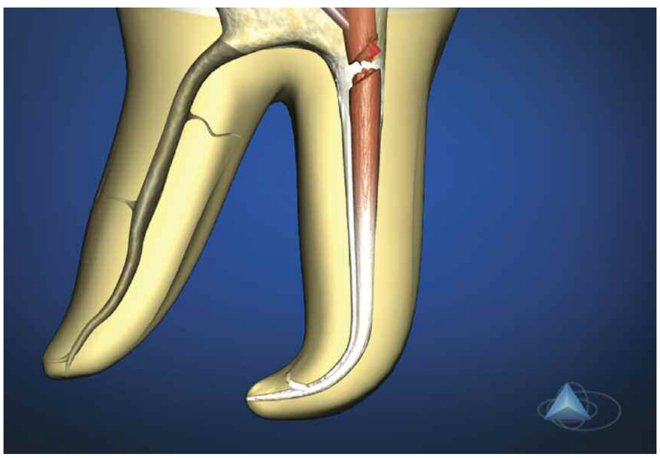

Figure 7a. *Activate the Calamus Pack handpiece, sear off the non-useful portion of the master cone, and note the transfer of heat through the gutta percha.*

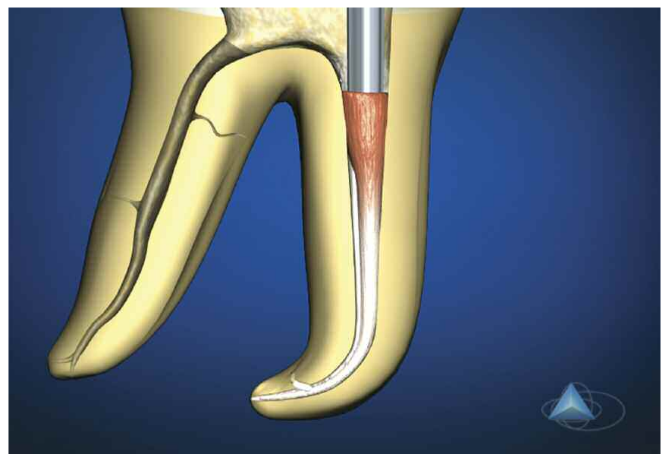

Figure 7b. *A large prefit plugger generates the first WOC and automatically compacts warm gutta percha vertically and laterally into the root canal system.*

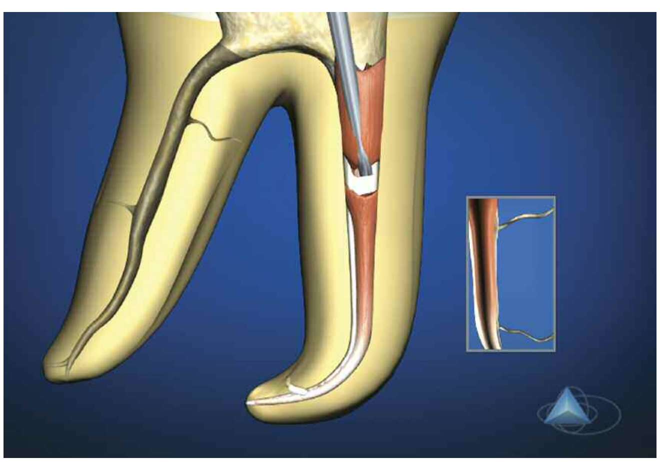

Figure 8a. *Upon activation, plunge the EHP 3 to 4 mm into the previously compacted material, deactivate, then remove, along with a "bite" of gutta percha.*

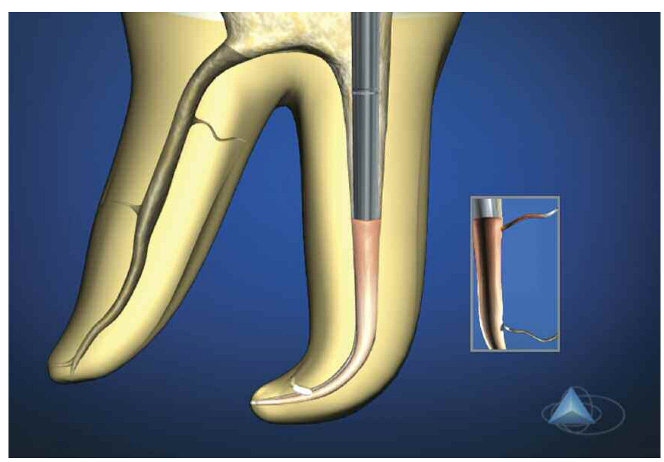

Figure 8b. *The medium prefit plugger carries a second wave of condensation deeper into the progressively narrowing and tapering preparation.*

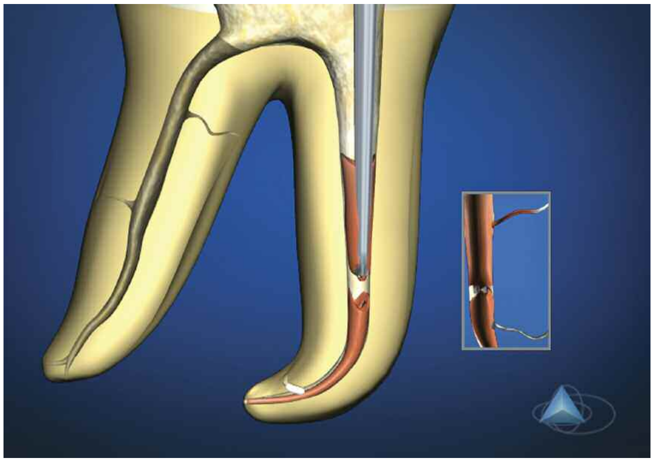

Figure 9a. Activate the EHP and plunge deeper into the gutta percha, deactivate, then remove the cooling EHP along with another bite of gutta percha.

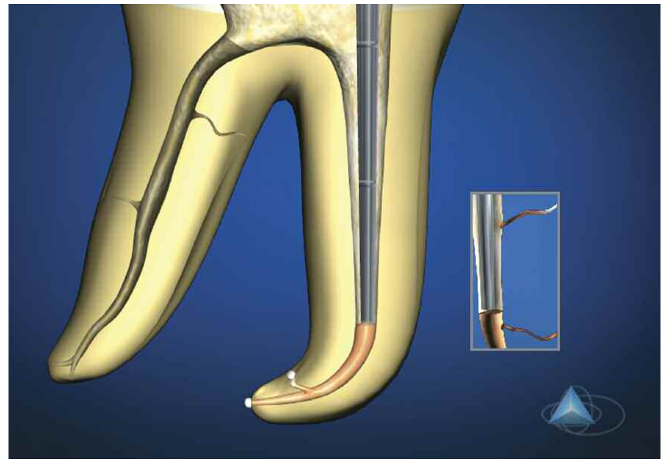

Figure 9b. The working end of the small prefit plugger scrapes the walls of the canal clean, maximizes the volume of gutta percha, and generates the final WOC.

master cone. Advantageously, the temperature of gutta percha only has to be elevated 3˚C above body temperature to become heat-softened and readily moldable. Utilizing this technique, obturation temperatures within the gutta percha have been shown to be clinically safe and generate working temperatures that range from 40˚C to 45˚C. Fortuitously, the temperature produced on the external root surface is less that 2˚C. This minor transfer of temperature is related to the fact that dentin is a poor conductor of heat; further, moisture within the PDL serves to wick off excessive heat.

Due to the efficient transfer of heat into the apical extent of the gutta percha master cone, the *small* size pre-fit plugger need not be placed closer than 5 mm from the canal terminus. This plugger is stepped around the circumference of the canal to maximize the volume of gutta percha available to achieve optimal hydraulics. A sustained 5-second vertical press with this plugger will deliver a controlled thermosoftened wave of warm gutta percha into the narrowing cross-sectional diameters of the prepared canal and result in apical corkage ***(Figure 9b)***. Again, a sustained 5-second press with this *small* size pre-fit plugger serves to offset shrinkage during the cooling cycle. Following the downpack, a working film frequently reveals filled accessory canals coronal to the more apical mass of gutta percha ***(Figure 10)***. When the root canal has been properly shaped and the root canal system cleaned, then the material occupying the lateral anatomy may be all gutta percha, all sealer, but is typically a mixture of both.

Calamus Backpack

When the downpack has been completed and the apical one-third corked, reverse filling the canal is important to eliminate radicular dead space. The Calamus Flow reverse filling technique, or what is termed the *backpack*, is easy, fast, and three-dimensional.

Thermosoftened gutta percha is readily dispensed into a shaped canal utilizing the Calamus Flow handpiece in conjunction with a 20 or 23 gauge cartridge. A new cartridge is selected and inserted into the heating chamber and secured by tightening the cartridge nut. A protective heat shield may be used to prevent inadvertent thermal injury and is inserted over the canula and the heating chamber portion of the handpiece prior to backfilling the canal. When the Calamus Flow handpiece is activated, an internal plunger travels toward the heating chamber and the cartridge, which is filled with gutta percha. In this manner, the plunger serves to push thermosoftened material out of the heated cartridge, through the canula, and into the canal.

The tip of the warm canula is positioned against the downpacked gutta percha for 5 seconds to re-thermosoften its most coronal extent ***(Figure 11a)***. This procedural nuance promotes cohesion between each injected segment of warm gutta percha. The Calamus Flow handpiece is activated and a *short* 2 to 3 mm segment of warm gutta percha is dispensed into the most apical region of the empty canal ***(Figure 11b)***. Injecting or dispensing too much gutta percha invites shrinkage and/or voids which result in poorly obturated canals judged radiographically. The Calamus Flow handpiece should be held lightly so it will "back-out" of the canal when injecting thermosoftened gutta percha into the canal.

Figure 10. Following the downpack, a working film demonstrates 3D corkage and filled lateral canals coronal to the more apical mass of gutta percha.

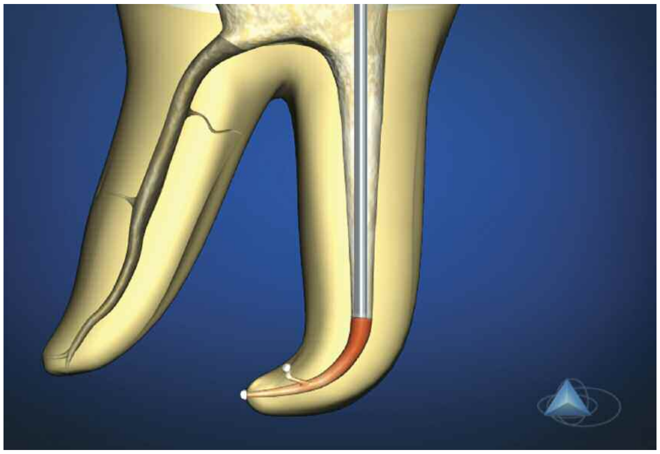

Figure 11a. The tip of the warm Calamus Flow canula serves to re-thermosoften the coronal most aspect of the previously packed gutta percha.

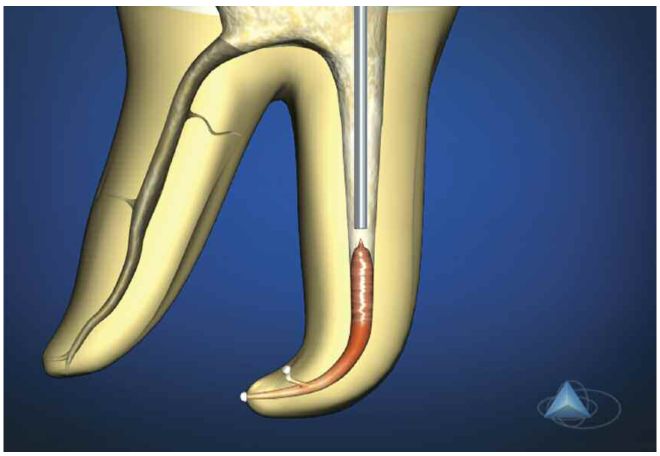

Figure 11b. Press the activation cuff on the Calamus Flow handpiece and dispense a small 2 to 3 mm segment of warm gutta percha into this region of the canal.

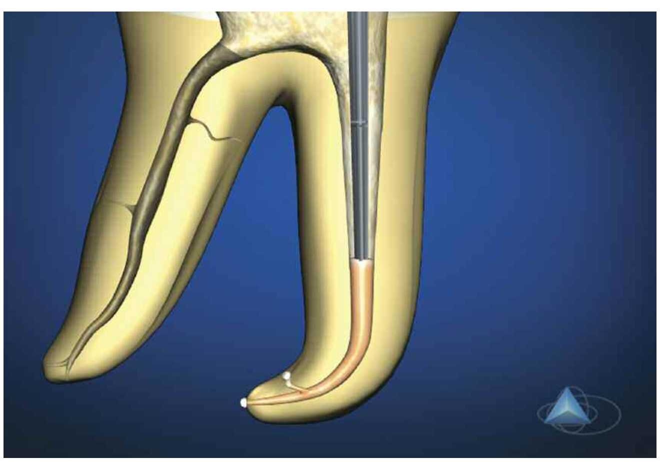

Figure 11c. The small prefit plugger is used to condense warm gutta percha and generate a reverse wave of condensation.

The small size pre-fit plugger is used, as previously described, to densely compact warm gutta percha into this region of the canal. Utilizing the plugger in this manner will capture the maximum cushion of rubber, promote successful hydraulics, and generate "reverse" waves of condensation ***(Figure 11c)***.

To continue the backfilling technique, dispense a *longer* 3 to 4 mm segment of warm gutta percha into this more coronal region of the canal ***(Figure 12a)***. The working end of the *medium* size pre-fit plugger is stepped circumferentially around the preparation to clean the dentinal walls, flatten the dispensed material, and deliver warm gutta percha, laterally and vertically, into this region of the canal. This plugger is used to press against the cooling gutta percha for 5 seconds to offset shrinkage during the cooling phase ***(Figure 12b)***. The backfilling technique continues, in the manner described, until the canal has been reverse filled ***(Figure 13)***. Alternatively, backfilling may be stopped at any level within the canal to accommodate a post to facilitate potential restorative needs.

To fill furcal canals, the pulp chamber floor of multi-rooted teeth is covered with a thin layer of sealer prior to dispensing gutta percha. An appropriately sized amalgam plugger is used to effectively compact thermosoftened gutta percha on the pulpal floor, which in turn, generates desirable hydraulics. Different horizontally angulated post-treatment radiographs may be taken to confirm the root canal system has been densely obturated, laterally and vertically, to the canal terminus ***(Figure 14)***. Frequently, a puff of sealer will be noticed adjacent to a portal of exit and should be considered irrelevant to the prognosis of the case. When the prepared apical foramen is relatively round, and if the master cone has been well fitted, sealer puffs will generally be larger laterally and smaller or nonexistent apically. Following obturation procedures, gutta percha and sealer are thoroughly excavated from the pulp chamber utilizing a solvent such as xylol or chloroform. A solution of 70% isopropyl alcohol is flushed into the pulp chamber to remove any obturation residues in preparation for the restorative effort. Scientific evidence has shown that flushing out the chamber, as described, will eliminate free eugenol and allow for predictably successful bonding.[15]

CONCLUSION

The Calamus Dual 3D Obturation System is innovative technology that may be utilized to fill root canal systems. 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. ▲

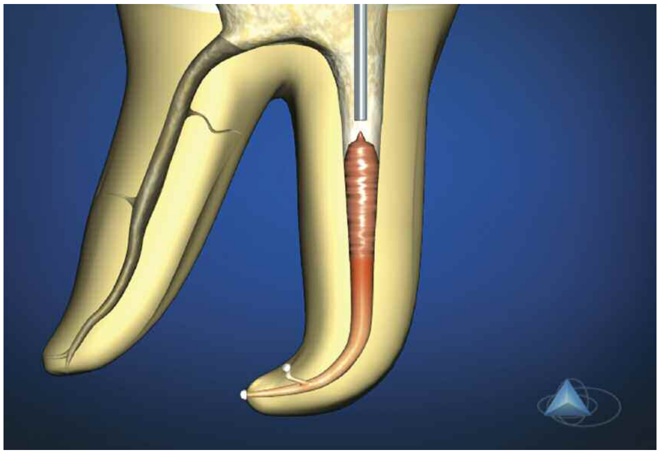

Figure 12a. The Calamus Flow handpiece is activated and a little longer, 3 to 4 mm, segment of warm gutta percha is dispensed into this region of the canal.

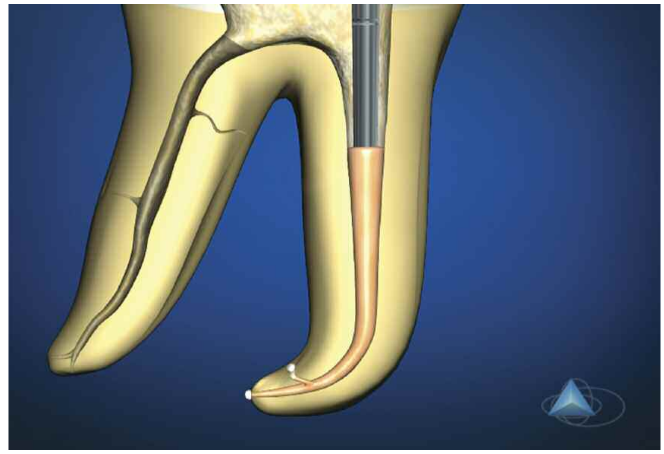

Figure 12b. A medium size, prefit plugger densely compacts warm gutta percha vertically and laterally into this region of the canal.

Figure 13. This graphic illustrates that the potential to fill root canal systems is largely dependent on shaping canals and three-dimensionally cleaning.

Figure 14. Complete endodontic treatment provides a predictably successful foundation for perio-prosthetics.

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