

Filling root-canal systems— The Calamus 3D Obturation Technique

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

_Virtually all dentists are intrigued by endodontic post-treatment radiographs exhibiting filled accessory canals. Filling root-canal systems represents the culmination and successful fulfilment of a series of procedural steps that comprise start-to-finish endodontics (Fig. 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. In order to maximise obturation potential, clinicians would be wise to direct treatment efforts toward *shaping* canals and *cleaning* root-canal systems.¹

Shaping facilitates 3-D cleaning by removing restrictive dentine, 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 deeply 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.^{2,3}

This article features the new Calamus Dual 3D Obturation System (DENTSPLY Maillefer; Fig. 3) that may be used to fill root-canal systems. 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 the

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

Fig. 3 The Calamus Dual 3D Obturation System combines a Pack handpiece for down-packing with the Flow handpiece for back-packing.



Fig. 2



Fig. 3

manner in which to use this technology to perform the vertical condensation technique. The clinician is encouraged to read, visualise and learn more about the manner in which to perform each procedural step that directly serves to influence filling root-canal systems; this includes performing the other hybrid warm gutta-percha techniques using Calamus technology.^{1,5}

_Vertical condensation technique

The objective of the vertical condensation technique is to carry a wave of warm gutta-percha along the length of the master cone continuously and progressively, starting coronally and ending in apical corkage (Fig. 4). The physical and thermo-molecular 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. While I have previously described the vertical condensation technique,^{11,12} this article represents the most recent advances in the manner in which to perform the warm gutta-percha with vertical condensation technique.

Cone fit and plugger selection

Traditionally, a medium-sized *non-standardised* 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 *standardised* 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 manual or mechanically driven file that was carried to the full working length.

The master cone is fitted in a fluid-filled canal to simulate more closely the lubrication effect that

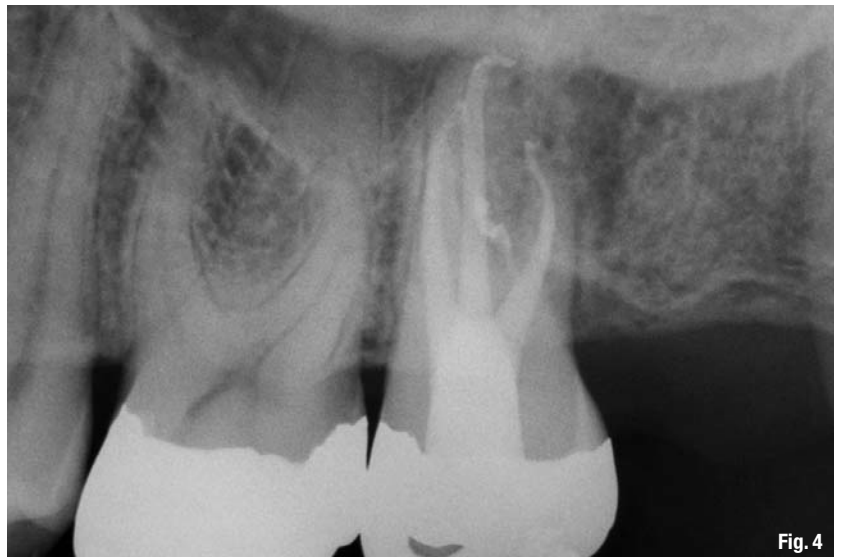
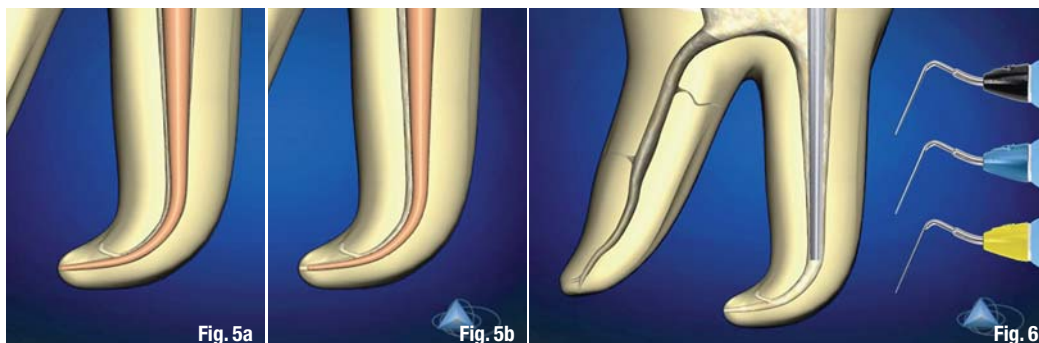


Fig. 4 A post-op film of a maxillary second molar. Note the abrupt apical curvature of the palatal system, recurvature of the DB system and the filled furcal canal.

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* tug-back upon removal. This master cone can be apically trimmed and further customised with glass slabs or a spatula, utilising either cold or heat rolling techniques. It is simple to fit a master cone into a patent, smoothly tapered and well-prepared canal.

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 1.0mm from the *radiographic terminus* so that its most apical end is just short of the *apical constriction* or the actual position of the *physiologic terminus* (PT; Figs. 5a & b). 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 utilising the paper point drying technique.¹²

Four manual pluggers, utilised to compact heat-softened gutta-percha, provide working end diameters of 0.5mm, 0.7mm, 0.9mm and 1.3mm (DENTSPLY Maillefer). Generally, a *larger*-sized plugger



Figs. 5a & b These animations demonstrate the master cone fitted to length and the master cone apically cut-back based on the paper point drying technique.

Fig. 6 The EHP that will loosely fit through the straightaway portion of the canal and optimally to within 5 mm from the full working length is selected.

Fig. 7a_The Calamus Pack handpiece is activated, the non-useful portion of the master cone seared off and the transfer of heat through the gutta-percha noted.

Fig. 7b_A large-sized, pre-fit plugger generates the first WOC and automatically compacts warm gutta-percha vertically and laterally into the root-canal system.



Fig. 7a

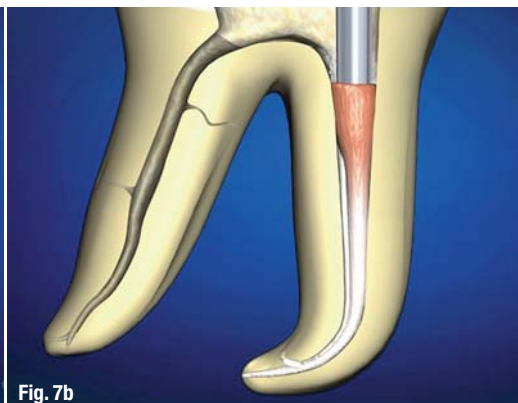


Fig. 7b

is selected that will work loosely, yet efficiently, over a range of a few millimetres in the coronal one-third of the canal. A *medium*-sized plugger is selected that will work passively and effectively over a range of a few millimetres in the middle one-third of the canal. In longer roots, a *smaller*-sized plugger may be required to work more deeply and safely to within 5mm of the canal terminus. Pre-fitting pluggers is essential and guarantees that when a plugger meets resistance, the plugger is on thermo-softened gutta-percha and not binding against unyielding dentinal walls.

Sealer and master cone placement

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 this cone can simply be re-buttered and re-inserted to ensure there is sufficient sealer present. Once the master cone has been 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. The Calamus Pack handpiece is the heat source that, in conjunction with an appropriately sized electric heat plugger (EHP), is utilised to thermo-soften, remove and condense gutta-percha during the down-packing 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 colours black, yellow and blue, corresponding to working end diameters and tapers of 40/03, 50/05 and 60/06, respectively (Fig. 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 utilised, in conjunction with a one-piece gutta-percha cartridge and integrated cannula, to dispense warm gutta-percha into the preparation during the back-packing 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 utilised to place a smooth curvature on the cannula. Ultimately, the gauge selected and the curvature placed should allow the cannula to pass through the coronal two-thirds of the preparation

Fig. 8a_Upon activation, the EHP is plunged 3 to 4 mm into the previously compacted material, deactivated, then removed, along with a *bite* of gutta-percha.

Fig. 8b_The medium-sized, pre-fit plugger carries a second WOC deeper into the progressively narrowing and tapering preparation.

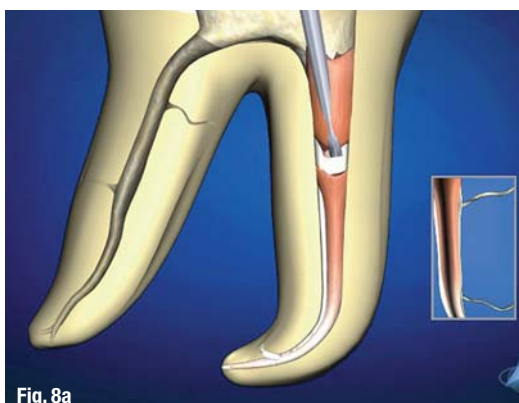


Fig. 8a



Fig. 8b

and to contact the previously down-packed master cone.

Calamus down-pack

In preparation for initiating the down-pack, 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. When the EHP cannot reach this desired level, in a well-shaped canal, the Calamus bending tool may be utilised 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 monitor its maximum depth of insertion safely.

Because of the thermo-molecular 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 serve to initially thermo-soften the master cone, maximise the volume of gutta-percha and effectively increase hydraulics when commencing with the down-packing phase of obturation.

The Calamus EHP is activated and utilised to sear off the master cone at the cemento-enamel junction in single rooted teeth or at the orifice level in multi-rooted teeth (Fig. 7a). In order to capture the maximum cushion of warm rubber, the working end of the *large-sized*, 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 press vertically on this flattened platform of warm gutta-percha for five seconds (Fig. 7b). This action serves to automatically fill the root-canal system, laterally

and vertically, over a range of a few millimetres and is termed a *wave of condensation* (WOC).⁴ Specifically, a WOC moves thermo-softened 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 offset shrinkage completely.

In order 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 for a brief second before removing the cooling instrument along with a *bite* of gutta-percha (Fig. 8a). Removing a bite of gutta-percha results in the progressive apical transfer of heat another 4 to 5 mm along the length of the master cone and facilitates the placement of the *medium-sized*, 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 WOC (Fig. 8b).

Depending on the length of the canal, only two, three or four heating and removal cycles are required until the pre-selected EHP can be placed within 5 mm of the canal terminus (Fig. 9a). Owing to multiple heatings, thermal cycling progressively transfers heat into the apical one-third of the gutta-percha master cone. Advantageously, the temperature of gutta-percha only has to be elevated 3°C above body temperature to become heat-softened and readily mouldable. Utilising this technique, obturation temperatures within the gutta-percha have been shown to be clinically safe and generate working temperatures that range from 40 to 45°C. Fortuitously, the temperature produced on the external root surface is less than 2°C. This minor transfer of temperature is

Fig. 9a The EHP is activated and plunged deeper into the gutta-percha, deactivated, then the cooling EHP removed along with another bite of gutta-percha.

Fig. 9b The working end of the small-sized, pre-fit plugger scrapes the walls of the canal clean, maximises the volume of gutta-percha and generates the final WOC.

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

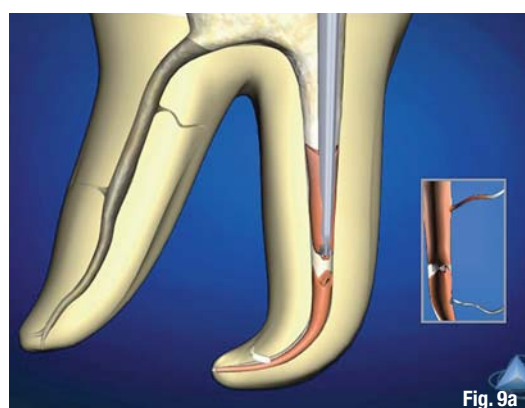


Fig. 9a

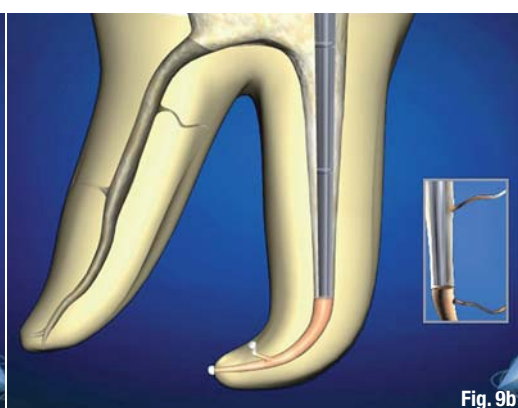


Fig. 9b



Fig. 10

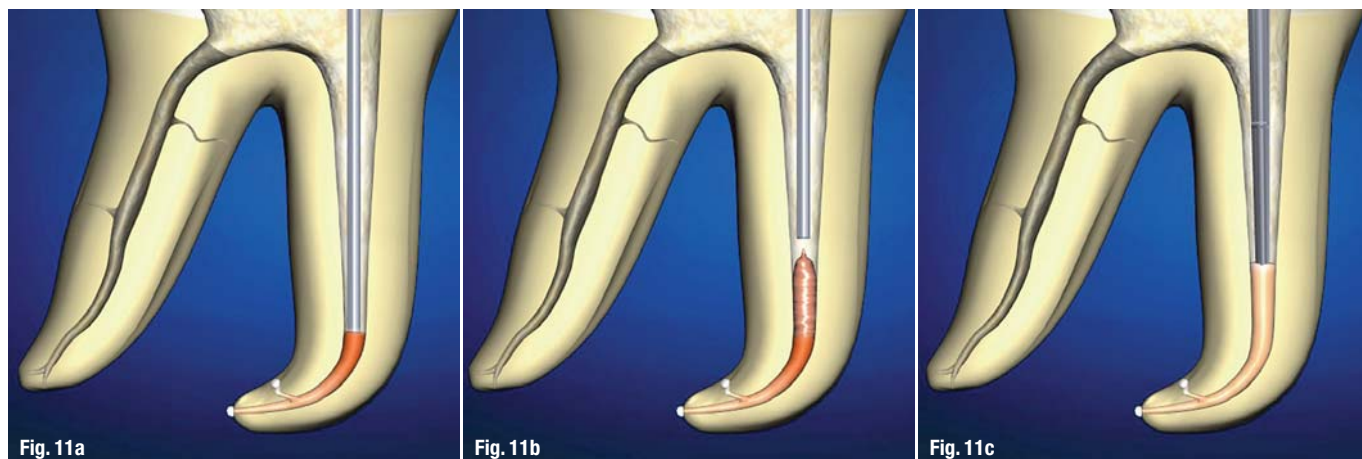


Fig. 11a The tip of the warm Calamus Flow cannula serves to re-thermo-soften the coronal most aspect of the previously packed gutta-percha.

Fig. 11b The activation cuff on the Calamus Flow handpiece is pressed and a small 2 to 3 mm segment of warm gutta-percha dispensed into this region of the canal.

Fig. 11c The small-sized, pre-fit plugger is used to condense warm gutta-percha and generate a reverse WOC.

Fig. 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.

Fig. 12b A medium-sized, pre-fit plugger densely compacts warm gutta-percha vertically and laterally into this region of the canal.

Fig. 13 This figure illustrates that the potential to fill root-canal systems is largely dependent on shaping canals and 3-D cleaning.

related to dentine being a poor conductor of heat; further, moisture within the periodontal ligament serves to wick off excessive heat.

Owing to the efficient transfer of heat into the apical extent of the gutta-percha master cone, the *small*-sized, 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 maximise the volume of gutta-percha available to achieve optimal hydraulics. A sustained five-second vertical press with this plugger will deliver a controlled thermo-softened wave of warm gutta-percha into the narrowing cross-sectional diameters of the prepared canal and result in apical corkage (Fig. 9b).

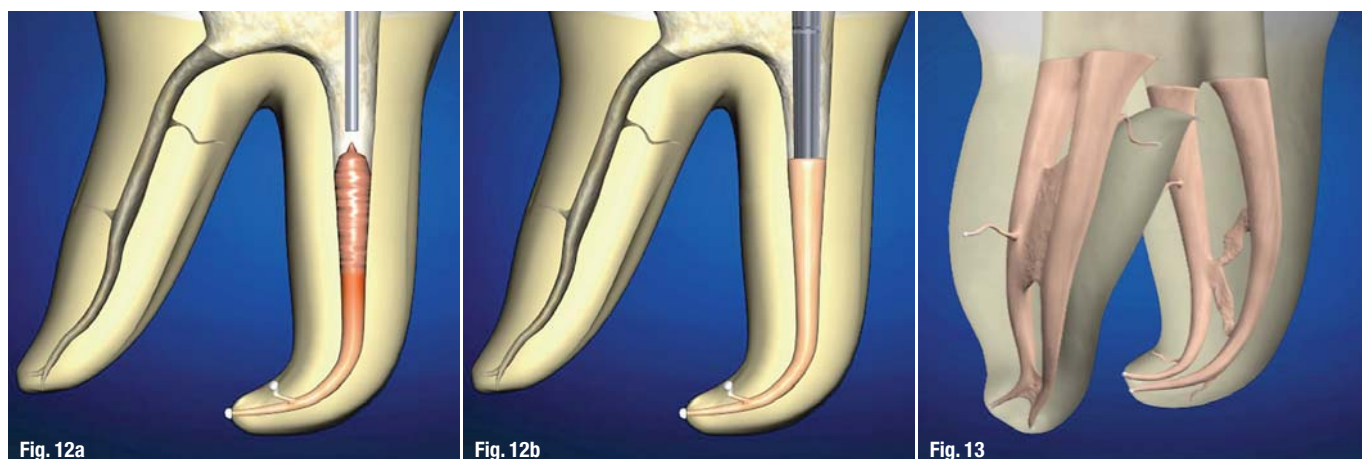
Again, a sustained five-second press with this *small*-sized, pre-fit plugger serves to offset shrinkage during the cooling cycle. Following the down-pack, a working film frequently reveals filled accessory canals coronal to the more apical mass of gutta-percha (Fig. 10). Once the root canal has been 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 back-pack

When the down-pack 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 *back-pack*, is easy, fast and 3-D.

Thermo-softened gutta-percha is readily dispensed into a shaped canal utilising 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 cannula and the heating chamber portion of the handpiece prior to back-filling 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 thermo-softened material out of the heated cartridge, through the cannula and into the canal.

The tip of the warm cannula is positioned against the down-packed gutta-percha for five seconds to



re-thermo-soften its most coronal extent (Fig. 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 (Fig. 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 thermo-softened gutta-percha into the canal. The *small*-sized, pre-fit plugger is used, as previously described, to densely compact warm gutta-percha into this region of the canal. Utilising the plugger in this manner will capture the maximum cushion of rubber, promote successful hydraulics and generate reverse waves of condensation (Fig. 11c).

To continue the back-filling technique, a *longer* 3 to 4 mm segment of warm gutta-percha should be dispensed into this more coronal region of the canal (Fig. 12a). The working end of the *medium*-sized, 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 five seconds to offset shrinkage during the cooling phase (Fig. 12b). The back-filling technique continues, in the manner described, until the canal has been reverse filled (Fig. 13). Alternatively, back-filling may be stopped at any level within the canal to accommodate a post to facilitate potential restorative needs.

In order 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 compact thermo-softened gutta-percha on the pulpal floor effectively, which in turn, generates desirable hydraulics. Different horizontally angulated post-treatment radiographs may be taken to confirm that the root-canal system has been densely obturated, laterally and vertically, to the canal terminus (Fig. 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 non-existent apically. Following obturation procedures, gutta-percha and sealer are thoroughly excavated from the pulp chamber utilising a solvent such as xylol or chloroform. A solution of 70% isopropyl alcohol is flushed into the pulp chamber to remove any obturation residues

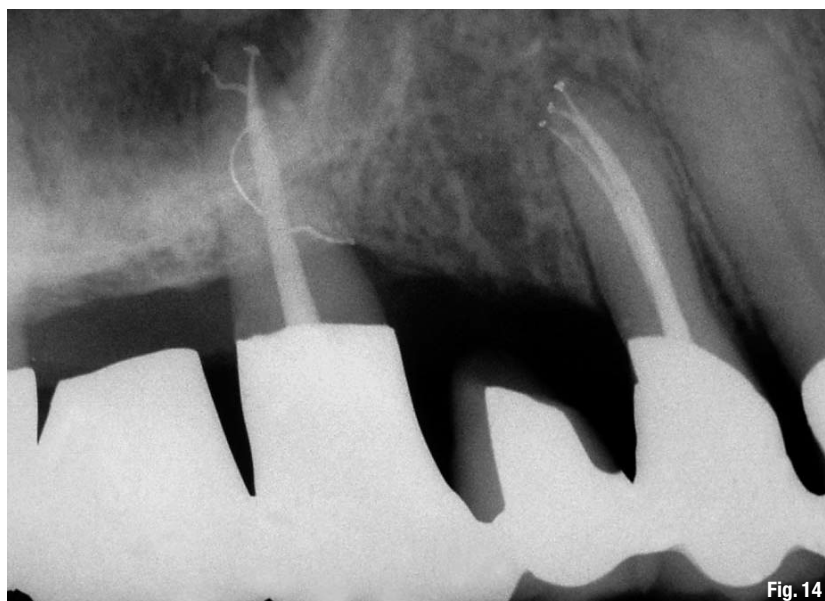


Fig. 14

in preparation for the restorative effort. Scientific evidence has demonstrated that flushing out the chamber, as described, will eliminate free eugenol and allow for predictably successful bonding.¹³

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

Conclusion

The Calamus Dual 3D Obturation System is innovative technology that may be utilised 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 recognised as the *ultimate dental implant*. When properly performed, endodontic treatment is the cornerstone of restorative and reconstructive dentistry.

Editorial note: A list of references is available from the publisher.

_about the author

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