Filling Root Canal Systems with Centered Condensation Concepts, Instruments and Techniques

L. Stephen Buchanan, DDS, FACD, FICD

Filling root canals seems to be the primary obsession of dentists providing endodontic therapy to their patients. This is because we (especially endodontists) are judged as clinicians by how ideal the fill looks after the case is finished. But the more fundamental cause of this focus is the common frustration dentists experience during the obturation procedure itself.

Ironically, problems encountered during filling procedures are most often not about obturation but are related to missteps during negotiation and shaping procedures.[1] If you never get to the end of a root canal during the negotiation phase of treatment, you will never shape or fill to that point afterward. When curved canals are blocked, ledged, or prematurely obturated by separated instruments, it is impossible to enjoy the fill unless you state that you *meant* to do that – that you like filling short apically.

Fortunately, our concepts, instruments, and techniques for the preparation of primary canals prior to obturation have never been so accessible to dentists having a wide range of talent and experience. With the use of patency clearing and lubricants during negotiation, apex locators for length determination, and variably-tapered nickel titanium files for shaping, ideal root canal preparations can be accomplished by novice dentists in nearly every case, thereby eliminating most of the frustrations inherent to obturating primary canals to any desired endpoint.[2]

Apical Extent of Filling

So now that root canal preparation is more a science than an art, how do we decide the ideal endpoint for filling? The best research I've read in answer to this question was done by, Sjogren, Figdor, Persson, and Sundqvist, [3] who looked at root canals filled short and long, with positive and negative culturing results in each group. They showed that high success rates were achieved regardless of long or short filling when the culture came back negative, but when the culture came back positive *only* the fully filled cases worked predictably. The authors theorized that success was achieved because the remaining bacteria were entombed in the canal. Infected or not, all of the cases worked when the canals were filled to or beyond the terminus!

For me this study proved two things; first, the old adage that we really don't even need to fill the canals in teeth, if we can just create a totally sterile environment inside root canal systems and place perfect seals coronal to them.[4] Second, because no one can insure sterility in any given root canal space, the surest chance of clinical success is gained when root canal systems, in all of their complexities, are filled to their full apical and lateral extents, even though that means that there may be surplus material beyond the confines of the root canal space.

Surplus Filling Material

What about all the studies reported in the literature that show a correlation of overfills to higher failure rates? How do we reconcile these findings with Sjogren and coworkers' results? There is a very straightforward but generally unrecognized difference between most of the studies done in the 60's, 70's, and 80's versus studies done in the last 14 years. Virtually all of those earlier studies looked at fills in preparations done with the apical stop technique.

By definition, an apical stop preparation cannot be overfilled (a stop is an intentional ledge form just short of the canal terminus) unless length determination was mistaken and the stop is non-existent. Sjogren et al[3] stated in their discussion that success in their overfilled cases was likely due to the specialist clinician's ideal preparation form which ensured an adequate seal. Schilder would describe this result as overextended but *not* underfilled.[5]

OK, that sounds logical, but what about surplus sealer? Why do clinicians who use lateral condensation fear sealer puffs while clinicians who use warm gutta percha techniques not only feel like they are nothing to fear but actually enjoy seeing them at the root surface in post-operative films?

This great difference in opinion also has a basis in many clinicians' experience. AH26 and Grossman's sealers (for decades the most commonly used sealers by clinicians doing cold lateral condensation) are not only extremely inflammatory but they take days to set, extending the time that their toxic effects are felt when they are pushed into periradicular tissues during obturation. It's no surprise that clinicians become gun-shy of sealer puffs when they so often have patients complain about pain in these circumstances.

Most warm gutta percha fills are done with Kerr Pulp Canal Sealer, a quick setting, well-tolerated sealer[6]--so clinicians who do techniques that fill lateral canals routinely seldom hear a patient complain about significant post-operative pain episodes, so they wonder what all the fuss about surplus sealer is about.

Lateral Extents of Filling

What about the lateral extent of our fills? Surprising to me, the importance of filling lateral and accessory canals is still controversial despite 35 years of arguing among specialists. Those who do "three dimensional" obturation techniques have historically claimed technical and even moral superiority over those who do techniques that only fill primary canals.[5] Those who use obturation techniques that are less effective in filling root canal aberrations claim that there is no credible research proving that filling lateral canals makes a difference in clinical outcome.[7]

In fact, if filling lateral canals is so important, what about all of those millions of endodontic cases filled with single cone or lateral condensation techniques? 30-50% of those canals had lateral or accessory ramifications, and at least 70% of them worked in spite of only the primary canals being filled? How do we explain that?

This mystery has an even more obvious answer that was recently offered by Dr. Haapasalos.[8] What Dr. Haapasalos found was a significant inhibition of bacterial growth in culture dishes around AH26 and Grossman's sealers. When single cone or cold lateral condensation fills are done with these sealers they are placed in primary canal spaces adjacent to unfilled lateral and accessory canals where these sealer's toxic effects can kill bacteria left in those side channels. You don't have to fill lateral canals as long as all of the bugs in them are dead.

Unfortunately, many side canals are 6-7 mm's in length (Figure 1), making it unlikely that they can be killed in this manner. So I choose to fill all canal forms as completely as I can so that I roll a bolus of filling material past any bacteria I have inadvertently left in side canals to entomb them, thereby achieving the same outcome as if I killed every bug in the space.

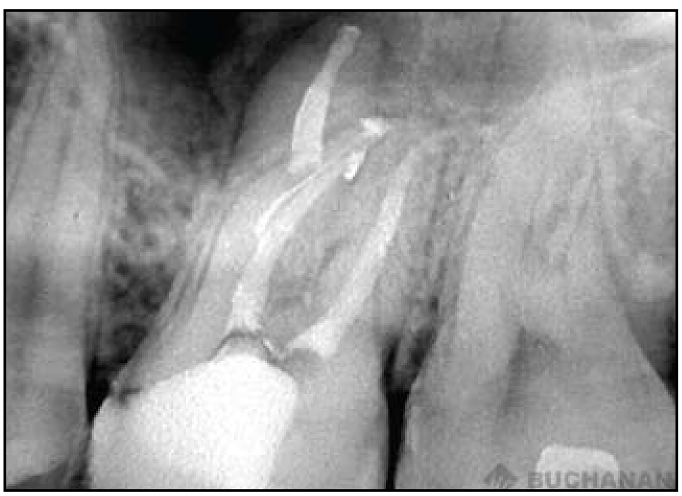

Figure 1. Maxillary molar with MB2 canal bifurcating off the MB1 canal and extending 7 mm's further before bifurcating again and exiting on the root surface. This side canal was non-negotiable and therefore most likely not sterile before obturation. Fortunately a bolus of sealer and warm gutta percha was rolled through its full length, entombing any remaining bacteria and allowing a success in spite of severe anatomic challenges.

Figure 2. Maxillary lateral incisor with wild anatomy, all of it filled in a single Continuous Wave downpacking movement (2.5-seconds).

Today, with Centered Condensation Techniques, it takes less training time and less chair-side time to fill lateral canals than it takes to do a good job of lateral condensation.[9] So for me, the question of whether to fill lateral canals or not seems like a no-brainer. With a Centered Condensation technique I can completely fill a root canal system with ten accessory canals in less than six seconds (Figure 2). Why would I work harder to avoid the thrill of the fill?

Centered Condensation

Centered Condensation obturation techniques efficiently and effectively move filling materials through root canal systems by driving the condensation device, be it an electrically-heated plugger or a pre-heated carrier, through the center of a thermoplastic material like gutta percha. The filling material, lubricated by the sealer cement, is displaced coronally as the condensation device moves apically, causing a streaming effect of the material against the primary canal walls filling lateral canals, accessory canals, fins, loops, and isthmuses in its wake (Figure 3).

When the condensation device closely approximates the geometry of the canal preparation, all of the lateral ramifications off the primary canal (assuming they have been cleaned out) are filled within 1-6 seconds, regardless of their number or extent. The apical accuracy of obturation is determined by the quality of the apical resistance form of the preparation and the fit of the filling cone in the Continuous Wave Technique or the accuracy of the apical extent of placement in the Carrier Technique.

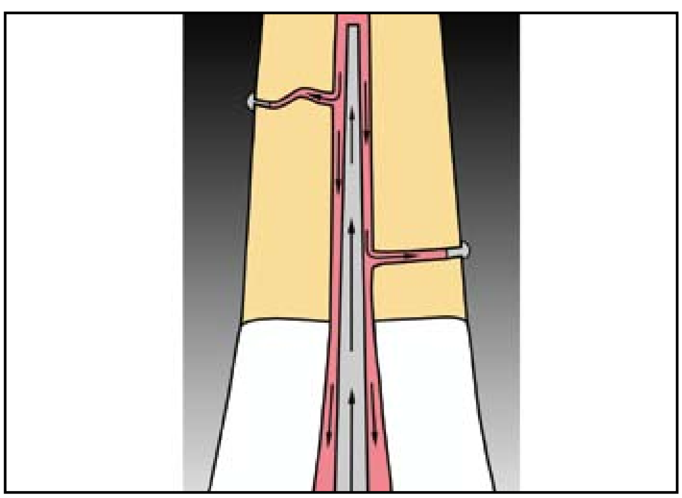

Figure 3. Schematic diagram of the streaming effect created as the condensation device is driven through the center of the filling material.

The GT *Series X* Obturator Technique

This technique requires a GT*X* Obturator of the same size as the final GT*X* File used to shape the canal to be filled (Figure 4), a scalpel for removing excess gutta percha from the carrier, paper points, sealer, and a GT*X* Obturator Oven.

The selected GT*X* Obturator is prepared by using the scalpel to cut off the gutta percha from its tip until approximately one and a half millimeters of the carrier end is exposed. In canals 17 mm's or longer this tip adjustment lessens the possibility for overfilling caused by the close fit of GT*X* Obturators in GT*X*-cut canal shapes. The rubber stop on the carrier is measured one millimeter short of length, as a sealer and gutta percha front that dimension develops and moves ahead of the carrier during its insertion through the canal.

A clever supplemental technique is to measure the distance from the reference point to the orifice level of the canal to be filled, to transfer that measurement from the preset stop down the shank of the carrier and to score the gutta percha at that length. By grasping the gutta percha on the carrier with a cotton plier's coronal to the score mark and twisting, the coronal surplus is removed, eliminating the need to later clean it out of the access cavity after placement of the GT*X* Obturator.

The prepared GT*X* Obturator is placed in the receptacle of the oven arm, hanging it by the handle, not by the stop. The oven arm is carefully lowered

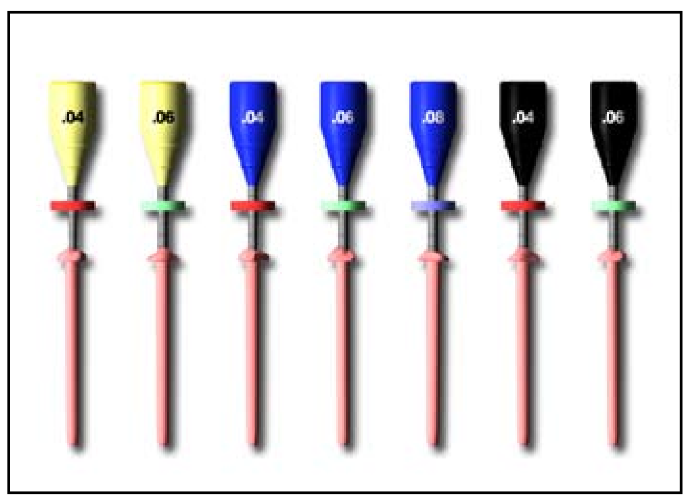

Figure 4. GT*X* Obturators sized to match the GT file shapes.

to its click stop and the correct Obturator size button is selected and pushed to prepare the oven for the heating cycle. If the clinician is not finished prepping the canal, the oven will hold a steady temperature for sixty seconds after the first beep.

The canal is dried and its length is confirmed with paper points, the canal is coated with sealer on a paper point, and all of the surplus sealer is blotted out with successive paper points. Initially the paper points will come out of the canal coated with sealer indicating a pool of sealer in the canal lumen, a set-up for surplus sealer being squeezed out the canal end during insertion of the GT*X* Obturator. When this pool of sealer has been removed, the next paper point will come out of the canal spotted, rather than coated with sealer.

Press down on the back of the oven arm and slowly allow the arm to rise. Place the tip of the carrier into the canal orifice and *slowly*, over 5-6 seconds, move it to its final position in the canal (Figures 5-8). Rapid insertion will result in unnecessary surplus being expelled beyond the root canal terminus.

Once the GT*X* Obturator is in place the carrier shank is cut at the orifice with a high-speed bur or ultrasonic tip before inserting the next Obturator in a multi-canalled tooth. If a post space is desired, the carrier is cut out of the coronal aspect of the canal with a Preppi Bur (a non-fluted high speed round bur) or an ultrasonic tip with a round end like the BUC-1 by Spartan Co.

Figure 5. GT*X* Obturator, showing gutta percha cut back from its tip, as it starts down the canal.

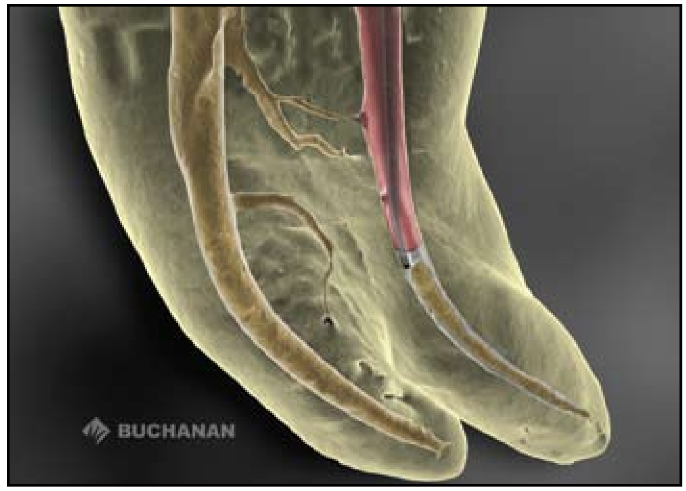

Figure 6. GT*X* Obturator further into canal showing gutta percha moving toward its tip as it pushes though the narrowing canal space.

Figure 7. GT*X* Obturator as gutta percha moves even with the carrier tip, Note the side canal beginning to be filled.

Figure 8. GT*X* Obturator in its ideal final position 1 mm short of the canal terminus showing the typical sealer and gutta percha front extending to full length with a small puff of sealer. Note the fill in the lateral ramification.

A New Device for the Continuous Wave Technique

SybronEndo has recently introduced the Elements Obturation Unit, the next generation of their System-B Heat Source, adding an inline motor-driven backfilling device so that the Continuous Wave of Condensation filling technique downpacking and backfilling can be done with a single electronic unit (Figure 9). The conveniently sized device can tip forward or back for optimal viewing of the display, it has quick-disconnect plugs on each handpiece cord, and has hangers attached to the unit that can be removed and mounted on a cart or cabinet. This device is also available without the box in a faceplate-configuration for cabinet mounting. Let me take a moment to walk through this device's upgrades and functionality.

The System-B Side of the Unit

The System-B Heat Source has been dramatically redesigned. First off, the handpiece itself has been enlarged to a more ergonomic diameter, similar to other dental handpieces. It has a removable (for sterilization) stainless steel sleeve with a silicon cover at its plugger end to give the operator a soft, comfortable grip. The actuating button is raised 2 mm's so it is easily located by touch and there is an indicator light just ahead of it so the operator can see when the heat source is activated – even if the sound signal is turned off.

Figure 9 The new System-B/Elements obturation device by SybronEndo. Detachable sleeves allow sterile handpiece surfaces and inline motor-driven extruder adds backfilling capability.

Secondly, the electronic control system has been upgraded to a much more sophisticated level. There are selection switches for each different heating functions; downpacking, backfilling and pulp testing with heat. This is a big advantage, as each of these functions requires different power and heat settings. Downpacking is typically done at 200^0 C; backfilling at 60^0 C (all in "touch mode"), and heat testing of pulps is done at 200^0 C in "continuous mode." Any of these settings can be changed and stored differently than the factory-set default values.

The downpacking mode has the safety feature of an automatic shutoff after four seconds to limit the amount of heat dialed into a root by novice dentists, after which the dentist must re-hit the button if more heat is needed in a long root. Also in the downpacking mode a convenience feature has been added: a sound is emitted at five seconds and another at ten seconds after cessation of the heating cycle. These signals, coming at the end of the downpack, tell dentists when they are ready for the separation burst of heat (after five seconds) or to tell them when they are ready to break the plugger loose if they are doing a single-cone backfill (ten seconds into the cooling cycle).

With those features aside, the most important upgrades to the System-B Heat Source are the electric heat attachments that can be inserted in the handpiece, which include stainless steel Continuous Wave electric heat pluggers, nickel titanium Continuous Wave electric heat pluggers, an electric heat pulp tester, and an electric heat tips for soft tissue cautery during surgery. Each of these tips has a hexagonal flange that allows quick insertion and directional stability without tightening a collet like the previous System-B Heat Source. This is very helpful when obturating a four-canalled molar that requires changing between four different pre-fitted Continuous Wave pluggers.

The stainless steel Continuous Wave electric heat pluggers have been around since the first introduction of the System-B Heat Source in 1996 but the geometry of these pluggers has been changed, and an .04 taper CW plugger has been added for a full range of .04 to .12 tapers in the standard shapes. In a big improvement, the tip diameters now vary with the tapers for more consistently ideal fitting in canals shaped to those tapers. The plugger geometries, listed with tip diameters first and their tapers second, are 30-.04, 40-.06, 50-.08, 60-.10, and 70-.12, each having continuous tapers (Figure 10).

As in the previous System-B, an electric heat tip is available for pulp testing. Before the System-B, heat testing was done with flame-heated gutta percha on a hand instrument — a scary and very inaccurate method. Consistency is everything with thermal testing to ascertain the relative vitality of pulps. Flame-heated gutta percha is continually cooling after it is taken out of the flame, sometimes just before the pulp reacts, and it is always a different temperature for each tooth tested. The introduction of electric heat application with the System-B Heat Source standardized, for the first time, this important test of pulpal vitality, allowing more dependable results in partially necrotic cases.

The Extruder Side of the Unit

The other handpiece on the Elements Obturation System is the motor-driven extruder that eliminates the need for a separate backfilling gun. The inline configuration provides a couple of advantages, the first being its ability to be placed in a standard hanger alongside high and slow-speed handpieces on a cart or cabinet. The second is the improved control this device allows the operator: the way it can be held in a pencil grip, so that the finger rests steady while in use, plus the ease of a motor drive over squeezing a trigger. With the added tactile feedback of this handpiece over a gun-type backfilling device, it is easier to feel the needle bumping back as the extruded material pushes it out of the canal and it is easier to avoid the void often caused by pulling the trigger to extrude the material and inadvertently pulling the needle out of the canal prematurely.

Figure 10 Continuous Wave electric heat pluggers, in sizes.04, .06, .08, .10, and .12 tapers (left to right), SybronEndo Co.

The software controls for this extruder allow for the use of synthetic gutta percha material such as RealSeal by SybronEndo. Simply toggling the second button down on the right until an "S" appears on the right-side display sets up a heating cycle that is lower in temperature and ends in five minutes, an important function for this excellent but heat-labile backfilling material.

The heating cycle for gutta percha and RealSeal is less than one minute when starting from a cold state, and is less than 20 seconds after changing cartridges. During this pre-heating process heat symbols animate below the thermometer. When temperature has been reached, the thermometer symbol is all red and the heat symbols stay solid.

The filling material cartridges designed for this device are very convenient as they are one piece with the needle and the holding nut. The sterling silver needle is pre-bent, obviating the need for a bending tool, and these needles come in 20, 23, and 25 gauge diameters. Because the needle and cartridge are self-contained there is no internal cleaning necessary between uses, and because the extruder has the same type of stainless steel sleeve as the System-B handpiece, external sterility is as simple as sliding on a clean outer covering.

The speed of extrusion is first set on the control panel by toggling the third button down on the right to show one or two arrows for slow or medium speeds, respectively. The final speed is selected on the handpiece toggle switch, with the back button for medium speed or the forward button for the fastest speed. After pre-heating is completed, one of the toggle switches on the handpiece is pressed until material extrudes out of the needle tip.

When the toggle switch on the handpiece is released the motor slightly retracts the plunger so material doesn't continue to extrude. If the needle is held in the canal orifice when the toggle switch is released, a slight suck-back of material will occur. If a corono-radicular build-up is to be placed into each orifice this is ideal, as the backfill will end about one millimeter short of the orifice. If the backfill is desired to the orifice level the needle should be pulled out just prior to releasing the toggle switch on the handpiece.

As with the Obtura II Gun™ backfilling device, the Elements needle is placed in the canal for five seconds to heat the canal wall a bit, and the toggle switch is pressed while the needle is lightly held in place. After the extruded material fills the backfill space ahead of the needle, the needle will be felt to bump back. With the extremely tactile pencil grip, and the motor-driven extrusion, a light touch is easily maintained, thereby holding backpressure on the extruding material and eliminating void creation.

Each cartridge holds enough material to backfill a complex molar (four or five canals) and when the cartridge is empty the motor automatically retracts the plunger in preparation for placing a new cartridge and needle in the extruder. If the operator wants to change the cartridge before it is totally empty, the left-facing arrow button is pressed on the control panel, which starts the retraction cycle. When the cartridge has emptied, an empty cartridge symbol appears on the display as well as under the handpiece. The cartridge nut is rotated to the left when facing the end of the extruder and removed before inserting a new cartridge into the heating chamber and rotating the new nut in the opposite direction to lock the new needle and cartridge in position.

The Continuous Wave Technique

A Continuous Wave electric heat plugger is selected to be of the same taper as the GT*X* File used to shape the canal or the same taper as the non-standardized gutta percha cone fit in a non-GT*X* shaped preparation. In multi-canalled teeth a separate plugger must be fit for each canal. The selected plugger, placed in the System-B / Elements Handpiece, is pushed into the canal and wiggled back and forth until it bottoms out. These pluggers are made of dead-soft stainless steel and the canal will bend them perfectly. It is critical that the selected plugger be fit into the prepared canal prior to cementation of the filling cone, not only to bend them but also to set the stop to a reference point on the tooth so the downpack can be ended before the binding point has been reached.

The final position the plugger will move to in the canal is checked by holding the stop on the prefit plugger adjacent to the pinch mark on the cone fit in that canal, and by comparing the tip of the plugger to the tip of the cone. If the plugger is too small it will downpack too close to the end of the filling cone, causing an unnecessary overextension of filling material. If the plugger is too large for the canal preparation, it won't get close enough to the end of the canal and it may fail to plastically deform the filling material in the apical third, possibly not filling an apical lateral canal.

If the plugger fits too close to length, choose a larger plugger. If a ML-.12 size plugger fits too close to length, simply shorten the stop and end the downpack short of 4 mm's from full length. If the plugger initially chosen doesn't fit close enough, choose a smaller size until appropriate length is achieved. Since the pluggers have continuous tapers and GT*X* Files have designated maximum flute diameters that cut canal shapes that are coronally parallel, it may be necessary to move down a taper size or even two sizes in long teeth.

After plugger fit is completed the canal is dried in preparation for cone cementation. As in all filling techniques, paper point confirmation of length allows one more chance to adjust length prior to the fill. The fit filling cone is buttered with sealer and the cone is slowly inserted into the canal to length, is moved in and out a couple of times and is seated to length.

Turn the System-B/Elements on and select the downpack icon, which will automatically set the power level and temperature. The cone is seared off at the orifice and the fat, stainless steel end of the

Figure 11 Continuous Wave Hand Pluggers, #'s 1 and 2. Note the small, flexible nickel titanium apical end and the larger stainless steel orifice end.

Continuous Wave Hand Plugger is used to condense the softened gutta percha at the orifice level. If a 20, 30, or 40 Series GT*X* File was used to shape the canal, a #1 Continuous Wave Hand Plugger is selected, if a .12 Accessory GT File was used a #2 CWH Plugger is used (Figure 11).

The cold CW plugger is placed against the gutta percha, and after applying apical pressure the switch is depressed, beginning the downpack. The CW plugger immediately heats at its tip and starts moving through the canal. When the plugger approaches its binding point in the canal, the switch is released while maintaining apical pressure. The plugger slows to a halt short of the binding point where a sustained condensation force is held for 5-10 seconds (Figures 12-14).

After the sustained condensation period is completed, a full second of heat is applied (this is called a separation burst), another one second pause without heat is held and the CW plugger is removed with the gutta percha that was displaced along its sides (Figure 15). Shorting the separation burst of heat is an invitation to pulling the cone out. If that happens, just put the cone, still attached to the CW plugger, back in the canal, do a two-second separation burst of heat, and the apical mass of gutta percha should stay in the root.

The small, flexible nickel titanium end of the #1 CW Hand Plugger is used to condense and set the apical mass of gutta percha (Figure 16). Be careful not to penetrate the apical gutta percha creating a cylindrical hole that will be a set-up for a void on the backfill.

Figure 12 The switched-on CW electric heat plugger begins its movement through the cemented gutta percha cone.

Figure 13 The CW Plugger is nearing its binding point and the switch has been released as apical pressure is maintained.

Figure 14 The CW plugger is in final position just short of the binding point, with a sustained condensation force being held. Note the lateral canals filled with sealer and gutta percha.

Figure 15 After a one-second separation burst of heat is applied, the CW plugger is withdrawn, leaving the apical mass of gutta percha.

Alternatively, in a straight canal, the Continuous Wave electric heat plugger can be removed by pushing apically and rotating without the separation burst of heat. This allows the gutta percha condensed alongside the plugger to remain in the canal as a set-up for a single cone backfill, the fastest and easiest backfill possible.

Backfilling is done with the Extruder. A #23 gauge needle works best in this application as long as it is held in the canal for five seconds before extrusion. This warms the canal wall to accept the syringed gutta percha without prematurely setting it and creating a void (Figure 17). Also important to avoid the void is to be sure that apical pressure be maintained on the needle during the backfill to create hydraulic pressure on the syringed material throughout the backfill (Figures 18, 19).

Don't Forget to Irrigate

Ironically, I've seen more irrigation failures since the introduction of rotary shaping than when we only used hand instruments. If you have shaped a root canal system in 90 seconds, it still needs 30-60 minutes of irrigation time to remove vital inflamed tissue from lateral ramifications or it needs to be

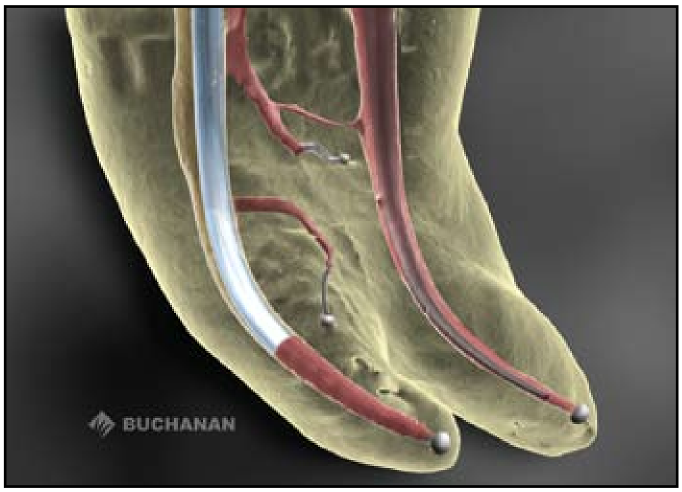

Figure 16 The small nickel titanium end of the #1 CW Hand Plugger is used to condense the apical mass of gutta percha until cooled and set.

Figure 18 After the extruded gutta percha fills the space ahead of the needle, it bumps the needle back. Holding a light apical pressure on the needle throughout backfilling creates the hydraulic force needed to eliminate voids.

Figure 17 A #23 gauge backfilling needle is placed to its binding point and is held in place for five seconds before gutta percha is extruded. This heats the canal wall, reducing the chances of a void in the backfill.

Figure 19 Completed obturation.

filled with calcium hydroxide for two weeks to kill the tissue left in those side spaces. Either will work but the calcium hydroxide will hurt for 72 hours as it fries the remaining tissue, then it will be totally comfortable.

The etiology for most failures can be diagnosed pharmacologically — it doesn't get any better on a week's worth of Augmentin or Clindamycin and it feels fine 45 minutes after the patient takes an NSAID like Naprosyn. Remove the root canal filling, soak it, fill it with calcium hydroxide for two weeks and refill it. In most of these cases I've seen a lateral canal filled on the second treatment. In most of these cases I've had resolution of all the symptoms.

Conclusion

It used to be difficult to fill root canal systems in three dimensions. Now it's a cinch. However, you cannot fill what you didn't clean out. Clean it out, and with today's concepts, instruments, techniques, and materials 3D obturation is simple, fast, and predictable (Fig. 20). Clean it out and experience *the thrill of the fill!*

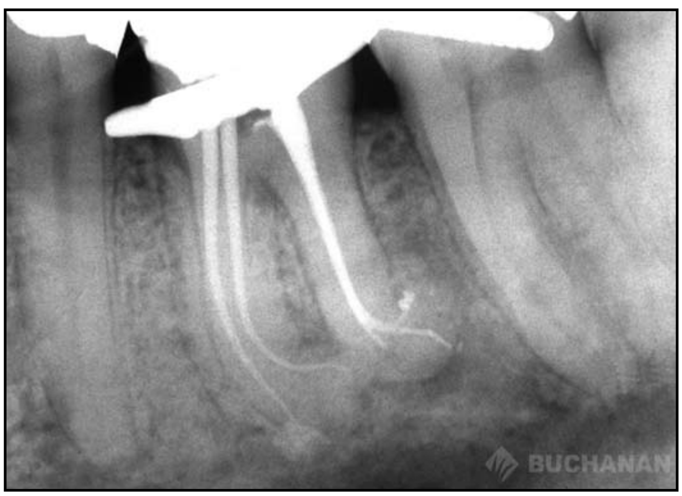

Figure 20 Mandibular molar obturated with a GT*X* Obturator in the distal canal allowing a 3D fill beyond the impediment located at the apical bend, and with the Continuous Wave technique in the smooth, but severely curved, mesial canals.

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