Endodontic Obturation Techniques: 
The State of the Art in 2015

Authored by L. Stephen Buchanan, DDS

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About the Authors

Dr. Buchanan is a Diplomate of the American Board of Endodontics, a Fellow of the National and International Colleges of Dentists, and part-time faculty at University of California, Los Angeles’ and University of Southern California’s graduate endodontic programs. He is the founder of Dental Education Laboratories, a hands-on teaching center in Santa Barbara, where he also maintains a practice limited to conventional/microsurgical endodontic therapy and implant surgery. He can be reached via the websites delendo.com and endobuchanan.com.

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OBTURATION: THE DRAMA QUEEN OF ENDO

Never was so much time and energy spent in the specialty with so small an outcome as in our understanding and application of root canal filling methods. I once saw Drs. Herbert Schilder and Franklin Weine go after each other on stage at an American Association of Endodontists (AAE) meeting many years ago, and their fight was about obturation; specifically, cold lateral versus warm vertical condensation. When I was just a sprout in dental school, Dr. Steve Cohen testified to a committee of the US Congress against Sargenti filling material (with complete photos of patients missing parts of their jaws).

And it continues to this day. Lateral condensation, a severely flawed method at best, is the most commonly taught obturation technique at dental schools worldwide (more about this later), despite the fact that few of their graduates will use the technique in practice (60% are using carrier-based methods, most of the rest are using single-cone obturation) (personal communication, 2005, with Dr. Gerald Glickman, past president of the AAE). The majority of American endodontists continue to harbor an irrational dislike of carrier-based obturation (Thermafi l [DENTSP LY Tulsa Dental Specialties]), and most of the dentists using continuous wave electric heat pluggers with System-B Heat Sources (Axis|SybronEndo) think they are doing vertical condensation fills when they hit the button and drive down through the gutta-percha master cone and sealer. Meanwhile, my friend Dr. Naseem Shah is telling me that we don’t actually need to fill the apical halves of root canals! How is it that so many very intelligent clinicians and academics can disagree so consistently on this topic?

This confusion, like pretty much everything else in root canal therapy (RCT), exists because procedural events in a tooth’s root canal system during treatment occur on a very small scale; and, they occur in a space that is obscured from our view, even when our radiographic imaging is stellar. Overlaying the confusion that dentists experience in the clinical environment, every dental company’s marketing people spend half of their waking hours thinking about how to distinguish their obturation products from the herd of competitors, resulting in a Babel Tower of obfuscation in print and lecture.

The Path to Mastery

So how do we think our way through these conundrums and make intelligent obturation choices going forward? To become clinically successful, we learn the concepts and procedures our instructors taught, we challenge them with our subsequent clinical experience, and bit by bit we gain a deeper understanding of these tiny “roach motels” that we call root canals. We practice with diligence, we add and we subtract procedural steps, we pay unforgiving attention to outcomes, and then we feed that data back into our model of endodontic reality, continuing a virtuous growth of our endodontic experience and skill.

If we are more passive about these choices, we are influenced by psychosocial factors, ie, where we were trained, how affluent our patients are (can they afford more time-consuming methods?), and how successful we think we have been with previous and current techniques (notice the word think). Nevertheless, the only predictable path to endodontic filling nirvana is the scientific route, despite both the severely limited data that we have and the frequently erroneous conclusions that we have made and continue to make. So let’s start at the beginning, with the most fundamental treatment issue of all.

It Begins With a Bug

It all starts with a bug in the pulp. Without bacterial invasion, pulps rarely cook off. So when we consider this carefully, it becomes crystal clear why, these days, fewer pulps degenerate 3 to 5 years after crown cementation. When I got out of school, this was common, and we explained to patients that the pulp was previously injured by decay and the procedure needed to restore the tooth and that it then slowly atrophied beyond the threshold of vitality. Today we understand this differently, as
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the bonded resin cements that have replaced zinc phosphate cement not only stick crowns to teeth, but also fill the opened dentinal tubules of cut tooth structure at the critical cemento-enamel junction level, dramatically reducing pulp deterioration 3 to 5 years post-cementation.

What we understand now is that 3 to 5 years was how long it took for zinc phosphate cement to wash out from under any crown margin less than perfectly adapted to the tooth, creating a path for bacteria into the poorly defended pulp space. Bonding resins have also dramatically increased the success of direct pulp capping, since it’s all about the integrity of the seal on what is essentially a hard-tissue sponge with somewhere between 3,000 and 33,000 dentinal tubules per mm².

Mysterious Failures

Without bacteria, we have no disease state, so cleaning remains the most critical aspect of root canal therapy. Ironically, cleaning procedures are given short shrift by many clinicians in many ways; the most common mistake being insufficient irrigation time. It is my belief that the current trend among endodontists going back to multivisit treatment is due to mysterious failures that they have seen after doing single-visit RCT without adequate irrigation time spent. Enterococcus faecalis notwithstanding, these are virtually all cases that began with severely inflamed pulps, and the continuing pain episodes unrelied by antibiotics are caused, in this case, by pulp remnants and not by unkilled bacteria, in my experience. However, the time it takes to digest pulpal remnants from lateral canal spaces with sodium hypochlorite (NaOCl) is about the same time it takes to reliably kill bacteria with NaOCl in a root canal, which is 40 minutes.³

Multivisit endodontic treatment resolves this problem with the use of chemical warfare—calcium hydroxide paste left in shaped canals for at least 2 weeks between appointments—killing infective agents, and pulp remnants with calcium hydroxide throughout 2 weeks rather than by the use of NaOCl for 40 minutes during a single appointment. Either way solves the problem; however, single-visit RCT is rightly loved by dentist and patient alike. Nobody wants a long and slow RCT, so effective irrigation and single-visit RCT is my preferred treatment plan.

On this topic, the change I made recently in my irrigation routine, using a chelating agent during all instrumentation and bringing NaOCl efficacy to bear afterwards, has roughly doubled the lateral anatomy I have seen filled. I made this dramatic change as I began to better understand the role smeared layer debris plays in limiting our NaOCl efficacy (Figure 1). So the “thril of the fill” is most seriously affected not by the filling procedure itself, but by the procedure that precedes obturation and irrigation: shaping.

Because we have no way to assess when our cleaning efforts have been adequately successful, we fill as completely as possible to deliver success regardless of whether bacteria remain, and we finish RCT by creating a robust coronal seal to keep future bacterial invasion at bay.

Lateral Condensation? No, Thank You!

If given the choice of having a single-cone fill or a lateral condensation fill of my own tooth, I would choose single-cone obturation every time. Contrary to Dr. Schilder’s calling the Lateral Condensation technique “single-cone filling with a conscience,” my beef with it is that it threatens the most critical aspect of RCT, which is the tooth’s structural integrity after treatment.

Think about it. To laterally condense more than a single accessory cone alongside the master cone of gutta-percha requires a shape usually cut with Gates Glidden bur sizes 4, 5, and heaven forbid, even a size 6. Then, after enlarging the canal unnecessarily (it’s weaker as a result), we wedge a very inclined-plane of an instrument we call a “spreader” tightly between the canal wall and the cold, unsoftened master cone, and we work it forcefully in an apical direction to make room for the accessory cone to follow. Can you say “splitting force”?

My sister, Dr. Jennifer Buchanan, was taught the Schilder filling technique at the University of California, San Francisco's School of Dentistry. One day, during her first clinical year, she called me to describe a filling technique that was being used at another school, where the gutta-percha wasn’t heated or softened prior to condensation. It made no sense to her, and she asked me if there were any other schools that also taught this lateral condensation obturation method. Funny, huh?

Single Cone Filling? Okay.

Beyond these issues, it is helpful to understand that short lateral canals can be filled all day long with single-cone obturation (Figure 1). Of course, this, like every other lateral filling, requires effective irrigation methods beforehand. Lateral canals are filled...
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during obturation procedures when an object (be it a plugger, a carrier, or just a gutta-percha cone) is moved into a canal containing viscous material that must stream coronally as it is displaced by the object, thus creating a hydraulic event capable of moving sealer into lateral canals.

When using the Single-Cone Filling technique, the most effective lateral hydraulic forces are delivered when the master gutta-percha cone tightly fits at its tip and closely fits the shape cut into the canal without binding anywhere along the cone, short of the cone tip. The most predictable shaping outcomes are delivered with radial-landed rotary files such as GT Series X Rotary Files (DENTSPLY Tulsa Dental Specialties) (Figure 2), which cut a consistent shape, allowing cones to fit tight at their tips with only a 0.05-mm gap between master cone and the primary canal wall (Figure 3).

**Centered Condensation Methods? Yes, Please!**

I am frequently asked how I rationalize using both The Continuous Wave (CW) of Condensation and Carrier-Based Obturation techniques in my practice and in my live course demonstrations. The answer is simple—they are both centered condensation methods. In other words, both of these obturation methods fill lateral canal aberrations with sealer and gutta-percha, in the same manner, by displacing surplus sealer and thermo-softened gutta-percha coronally as a heated plugger or carrier is driven through the canal during obturation. It is this displacement force, this streaming effect, that moves filling materials laterally (Figure 4).

The best conceptual explanation for the mechanics of centered condensation I’ve come up with is that centered condensation operates like the inverse of impressioning hydraulics. Impressions are typically taken with a hard tray that carries and pushes the heavy-body impression material around dental structures, and the heavy-body material slips and slides on the light-body impression material, which captures the finest details. Like impressioning, all these actions happen very quickly. Similarly, the quality of the root canal filling will not be improved by working at it for a longer length of time.

The physics of CW and Carrier-Based Obturation are similar: the electric heat plugger and carrier inversely act like the impression tray, the heavy-body material is thermo-softened gutta-percha, and the light-body material is the sealer (Figure 5). This is good to know as it informs us about optimal execution of these 2 Centered Condensation techniques.

The impression tray is not supposed to bind any of the patient’s dental structures; neither is the electric heat plugger or carrier supposed to bind opposite canal walls. These devices carry and move the heavy-body material, but they are always held short of their binding points in the canal. This is because once the plugger or carrier binds opposing canal walls, condensation of sealer and/or gutta-percha has ended. This is one
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reason I recommend that carrier-based obturators be held 1.0 mm short of canal length (more on this later).

Centered condensation methods are superior to vertical condensation in simplicity, in predictability, and in the quality of outcome. This is in no way critical of Dr. Schiller’s Vertical Condensation of Warm Gutta-Percha Obturation technique, because he set the standard for decades. Both centered condensation methods described in this paper were designed by Dr. Ben Johnson and me to qualify as next-generation procedural upgrades to decrease technique sensitivity by reducing the number of instruments and procedural steps needed, while still achieving the obturation results that Dr. Schiller taught us to expect. Who knew centered condensation, with its 2- to 5-second fills, would more consistently move sealer and gutta-percha (Figures 5 to 7) into lateral canal spaces than a technique that required 10 minutes per canal?

The Continuous Wave of Condensation Obturation Technique

This technique has been taught and used by a majority of endodontists around the world, so most procedural info about it is on the Internet in detail. However, please permit me to review a few of the critical technique issues attendant to the CW of Condensation Obturation technique.

The new, new thing in CW obturation is the elementsfree Obturation System (AxisSybronEndo) (Figure 8). For the first time, there is a cordless obturation system that operates exactly as the corded version, hitting 300°C within 0.5 seconds, then dropping to 200°C for the next 3.5 seconds, at which time it shuts off to reduce potential overheating of root structure. If further heat is required after the automatic shutoff, simply releasing the switch and pressing it again begins the next 4-second heating cycle.

The elementsfree cordless backfilling extruder is identical in nearly every way to the motorized backfilling device in the standard-setting Elements Obturation Unit (EOU) (AxisSybronEndo). The only difference I have experienced is that the elementsfree backfilling extruder shuts off after 4 minutes if it is not on the charging stand when it is switched on. This can be frustrating if a wait time is required to reheat it after automatic shutoff; the reason I switch my extruder on before I begin cementing master cones, so it is fully heated whenever I get to the backfilling procedure.

I am still surprised how few dentists who use a System-B, EOU, or now an elementsfree system, know about AxisSybronEndo’s Autofit Backfill gutta-percha cones (Figure 9). There is a backfilling cone sized for each CW electric heat plugger (.06, .08, .10, and 12 tapers), with tips sized at 0.40 to 0.45 mm. When sized in a Gutta

Figure 5. Sagitally dissected mesial roots of mandibular molars showing sealer and gutta-percha filling the isthmuses between the primary canals. The left root was filled with Thermafil Obturators (DENTSPLY Tulsa Dental Specialties) and the root on the right was filled with the Continuous Wave (CW) of Obturation Technique (courtesy of Dr. Robert Sharp).

Figure 6. A young mandibular premolar is seen in CT imaging to have apical branching of the primary canal. This case was treated with very little enlargement, as the primary canal had nearly perfect shape before it was entered. Before cutting any dentin in the canal, it was gaged with Ni-Ti K-files, sizes 20, 30, and 40, revealing a natural 30-.06 shape, so only a 30-.08 GTX rotary file was used to cut dentin—in the presence of 17% ethylenediaminetetraacetic acid solution—followed by 45 minutes of 6% sodium hypochlorite irrigation soak time. Note the 4 lateral canal exits adjacent to the primary portal of exit. This was filled with a GuttaCore Obturator (DENTSPLY Tulsa Dental Specialties).

Figure 7. Tooth No. 18 was a typical C-shaped second molar—separate distal and ML canals, an MB loop between the middle third and orifice of the ML canal. The 2 dominant canals either crossed paths, or they met in the apical third and abruptly curved in opposite directions before exiting the root. I was unable to find the MB canal form; however, effective irrigation and CW condensation with the elementsfree Obturation System (AxisSybronEndo) filled it from a retrograde direction.

Gauge (Lexicon [DENTSPLY Tulsa Dental Specialties]) to .55 mm, these backfill cones will fit ideally in the space left by any of the 4 CW plugger tapers. After tip adjustment, simply coat the backfill cone with AxisSybronEndo’s Pulp Canal Sealer, place it into the backfill space left by the CW plugger with a pumping action, remove it to recoat it with sealer and after replacing it in the backfill space, seal it off at the orifice with a CW plugger and firmly condense with a sustained condensation force until the gutta-percha has cooled and set hard.
Carrier-Based Obturation

Carrier-Based Obturation is fairly simple, but highly technique sensitive. There are just a few procedural steps, so each of them is critical and must be done correctly or poor results can occur. For instance, if too much sealer is placed in the canal before the heated obturator is taken to place, the obturator will act as a squeegee and shove all the surplus sealer out the end of the canal, which is not good, but worse is not having enough sealer in the canal prior to placement of the obturator. The carrier and gutta-percha will move very easily through the canal unless this dynamic system runs out of sealer coating the canal walls. In this case, the obturator will arrive at length without gutta-percha or sealer around its tip. Remember the impression tray analogy—without the thin-bodied impression material, the heavy-body material cannot pick up the detail because it doesn’t have the thin-bodied material to grease its way around the teeth. The same goes for the movement of thermoplasticized gutta-percha and sealer in centered condensation methods.

Holding the carrier 1.0 mm short of the full length of the canal creates a safety feedback loop that tells a dentist with the first post-obturation radiograph that the sealer application was inadequate, allowing for an immediate redo of the fill; 5 to 10 minutes at the time, but one or 2 hours if the case fails later. Most endodontists are concerned about gutta-percha wiping off the carrier when they are placed around a canal curvature, and nothing could be further from the truth. The only time carriers are stripped clean of gutta-percha is when sealer is placed inadequately or if it is over-blotted with paper points prior to obturator placement.

The latest advance in carrier-based obturation is GuttaCore obturators [DENTSPLY Tulsa Dental Specialties] (Figure 10). Instead of the medical grade PEEK polymer used in Tulsa’s obturators until recently, their R&D department has finally created what Dr. Ben Johnson, the inventor of Thermafil, had envisioned a decade earlier. Although a bit less robust than plastic carriers, GuttaCore carriers are easier to sever at the orifice level after placement and much easier to cut out in preparation for post spaces. As seen in Figure 6, GuttaCore Obturators, just like conventional carriers, are extremely 3-D.

My prediction is that GuttaCore Obturators will finally allow endodontists to use Carrier-Based Obturation with their self-esteem intact. This will be great for all—general practitioners (GPs), endodontists, dental companies, and, of course, the patients. Most GPs already know Carrier-Based Obturation to be not only a credible filling method, but an exceptional way to achieve “the thrill of the fill.” When endodontists wake up to carrier filling, they will save significant amounts of procedural time, especially in molars. The dental companies will finally get feedback from
endodontists who fill with obturators, and obturator techniques will get better with endodontists' expert attention to procedural detail and the inevitable improvements to technique that will result. Patients will also benefit, because nobody wants a long and slow RCT.

CLOSING COMMENTS
How to explain the wide range of opinions among endodontic specialists? My best guess is that it happens because we know so little about the procedures that we use to treat root canals, and because almost nobody dies when RCT fails; at worst, the patient gets a titanium replacement, and life goes on. If more people died more often from bad RCT outcomes, there would be $100 million of research grant money burning a hole in the National Institutes of Health's pockets to find out every little detail that influences the success and failure of endo treatment. Then we would have far fewer disagreements about how to do it successfully, but as it is, we have to figure most of this stuff out by empiricism, so arguments will continue.

Advances in the field have given us 2 different ways to achieve the same, very 3-D centered condensation result in mere seconds; now both of them are used without cords (Figure 11). So, where do I see obturation headed in the future? Well, I am still processing what Dr. Naseem Shah¹ has shown; that we can achieve total periapical healing without filling the apical half of the root canal; provided we use calcium hydroxide treatment between appointments to disinfect the apical half and then absolutely seal the coronal half with MTA. Dr. Shah¹ theorizes that she is causing apical regeneration of healthy tissue into the ends of these previously necrotic canals. I haven't seen research confirmation of that specific outcome, but I've seen the 50-plus cases she and Dr. Logani² wrote about in their paper; all had necrotic canals with significant peri-radicular lucencies, and nearly every one of them healed within 2 to 3 years. So, I am getting the feeling that the big event here is the 100% coronal seal provided by the MTA placed to midroot level. Everybody in dentistry questions the longevity of bonded composite sealing. Could it be that we are seeing unnecessary RCT failures because the coronal seals we place after RCT are not as robust as we think?

References
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POST EXAMINATION QUESTIONS

1. Lateral condensation, a severely flawed method at best, is no longer the most commonly taught obturation technique at dental schools worldwide.
   a. True  
   b. False

2. The resin cements that have replaced zinc phosphate cement not only stick crowns to teeth, but also fill the opened dentinal tubules of cut tooth structure at the critical cement-enamel junction level, dramatically reducing pulp deterioration 3 to 5 years post-cementation.
   a. True  
   b. False

3. The time it takes to digest pulpal remnants from lateral canal spaces with sodium hypochlorite (NaOCl) is about the same time it takes to reliably kill bacteria with NaOCl in a root canal, which is about 2 minutes.
   a. True  
   b. False

4. When using the Single-Cone Filling technique, the most effective lateral hydraulic forces are delivered when the master gutta-percha cone tightly fits at its tip and closely fits the shape cut into the canal without binding anywhere along the cone, short of the cone tip.
   a. True  
   b. False

5. The physics of Continuous Wave and Carrier-Based Obturation are similar: the electric heat plugger and carrier inversely act like the impression tray, the heavy-body material is thermo-softened gutta-percha, and the light-body material is the sealer.
   a. True  
   b. False
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6. According to the author, Vertical Condensation is superior to Centered Condensation methods in simplicity, in predictability, and in the quality of outcome.
   a. True  b. False

7. Carrier-based obturation is complex and highly technique sensitive with many procedural steps.
   a. True  b. False

8. Holding the carrier 1.0 mm short of the full length of the canal creates a safety feedback loop that tells the dentist with the first post-obturation radiograph that the sealer application was inadequate.
   a. True  b. False
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Please check the correct box for each question below.

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2. q a. True  q b. False  6. q a. True  q b. False  
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