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Welcome to paradise

As I am writing this, I am getting ready to travel to Honolulu for the American Association of Endodontists’ meeting. Hawaii is a wonderful place to visit, and I am thrilled that AAE is holding its annual session this year in paradise. You might very well have picked up this copy of roots at the event.

In this issue, be sure to read the report on tools for endodontic instrumentation by Dr. Rich Mounce, and the article on the new TrueTooth replicas by Dr. L. Stephen Buchanan.

Every issue of roots also contains a C.E. component. By reading the article on obturation by Dr. John Stropko, then taking a short online quiz about his article at www.DTStudyClub.com, you will gain one ADA CERP-certified C.E. credit. Keep in mind that since roots is a quarterly magazine, you can actually chisel four C.E. credits per year out of your already busy life without the lost revenue and time away from your practice.

To learn more about how you can take advantage of this C.E. opportunity, visit www.DTStudyClub.com. Annual subscribers to the magazine ($50) need only register at the Dental Tribune Study Club website to access these C.E. materials free of charge. Non-subscribers may take the C.E. quiz after registering on the DT Study Club website and paying a nominal fee.

I know that taking time away from your practice to pursue C.E. credits is costly in terms of lost revenue and time, and that is another reason roots is such a valuable publication. I hope you will enjoy this issue of roots and that you will take advantage of the C.E. opportunity.

For those of you who are in Hawaii for the AAE, please say hello to me in person. It is always a pleasure to rub elbows with others in the specialty. Roots Managing Editor Fred Michmershuizen is also here. Watch for his report on the meeting, plus lots more educational articles, in the next issue of roots.

Until then, I wish you all the best.

Sincerely,

Fred Weinstein, DMD, MRCD(C), FICD, FACD
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The image is of a TrueTooth™ training replica. Designed by Dr. L. Stephen Buchanan and re-created by a 3-D printer, these are authentic replicas of the internal and external anatomy of CT-scanned extracted teeth, with bleach-dissolvable material in the root canal passageways. TrueTooth training replicas are available exclusively from www.DELendo.com and are patent pending.
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—Ken Blanchard

Abstract

The author has been in private practice and a continuing student for the past 50 years. The first half was spent practicing restorative dentistry, and the second half in a specialty practice limited to endodontics. On the road to predictability, it became apparent there was a definite relationship present between root canal treatment, periodontal status, prosthetics and/or subsequent restorative procedures. Each operator has to decide what steps for a more predictable outcome they are willing to trust another to do. This article is an attempt to share some “secrets of success” and perhaps serve as a checklist for a system that works in the attempt to achieve predictability of endodontic treatments.

During the earlier years of the past century, several techniques were devised for the obturation of the canal system after removal of the diseased pulp, or necrotic tissue. Some of the most popular were silver points, lateral condensation of gutta-percha (GP), Sargenti paste and chloropercha. Currently there are seven techniques that utilize gutta-percha as the obturation material of choice:  
1) Single cone  
2) Lateral condensation  
3) Chloropercha technique  
4) Vertical compaction of warm GP (Schilder, continuous wave, System “B,” McSpadden, System “A”)  
5) Carrier-based (Thermafil)  
6) Injection of thermo-plasticized GP (often referred to as “squirting” using a Calamus or Obtura unit)  
7) Mechanically assisted compaction (Pac Mac).

In 1967, Dr. Herb Schilder, often referred to as “the father of modern endodontics,” introduced the concept of filling the root canals in three dimensions. The Schilder Technique involved a new and different approach for obturation of the canal system and resulted in much controversy.

Evidently, the controversy did create interest from some doctors, because in the mid 1970s new ideas and techniques evolved that became most of what are the currently accepted concepts of modern endodontic principles and techniques. Today, the numerous clinical reports, published research and the rapid advancements in technology have significantly changed the operator’s obturation preferences. Ease of communication, along with modern marketing, has become a very important determinant when making a choice of techniques.

More recent studies have discounted some previous obturation materials that were popular, but some form of GP still remains the most acceptable and widely used. The purpose of this article is to share a simple, six-step protocol (System “S”) in a straightforward manner, to achieve predictability of endodontic treatment for the benefit of the patient.

There are six important components to the System “S” protocol:  
1) Proper shaping with patency  
2) Adequate cleaning, disinfection and drying  
3) Delivery of pre-warmed GP to apex (Calamus/Obtura)  
4) Coronal seal for the rest of the system  
5) Respect for the endo-pros relationship  
6) Use of the surgical operating microscope (SOM) for the entire endodontic treatment.

The author believes that as long as the gutta-percha is introduced to the apical third of the canal system, pre-warmed and pre-softened, the deformation and adaptation to the canal walls is more predictable, resulting in a better seal that is significantly less "sealer-
dependent." It has been shown that the pre-warmed techniques (Obtura and Thermafil) produce a better seal than lateral condensation. Due to the lack of deformity inherent at room temperature, the techniques utilizing non-softened GP are more "sealer-dependent." The two most popular thermoplastic obturation techniques are the "carrier-based" (e.g., Thermafil) and "direct injection" (e.g., Calamus/Obtura). The pros and cons of each will be discussed, but regardless of the technique used, the "shape" of the prepared canal system is of utmost importance and must be discussed.

**Access and shaping the canal system**

In the early '70s, Schilder clearly stated the requirements for the proper shape using GP to achieve three-dimensional obturation of the canal system:

1) The root canal preparation should develop a continuously tapering cone shape.
2) It should have decreasing cross-sectional diameters at every point apically and increasing at each point as the access cavity is approached.
3) It should have multiple planes, which introduces the concept of "flow."
4) The foramen should not be transported.
5) The apical opening should be kept as small as practical in all cases.

There were several other requirements more clinically definitive. Following are a few of them: After placement of the rubber dam, an appropriate access is made. Unless the access is large enough for adequate vision, appropriate instrumentation may be compromised and canals missed. A perfect example is a maxillary first molar; if the access is made as though there was an MB2, it is amazing how many times an MB2 is found. A general rule of thumb is, if you access for it, you are more likely to find it. A proper access will also facilitate the creation of the continuously tapering shape of the canal, necessary for the warm GP technique.

Occasionally after caries or old restorations are removed, a "pre-endodontic" restoration may be required to control and maintain a sterile environment until the endodontic treatment is complete. This can usually be accomplished using a bonded composite technique.

Shaping should be confined to the anatomy of the canal system, following the natural curvatures. Instrumentation beyond the apex is unnecessary and may needlessly enlarge and deform the apical foramen. Using the Schilder protocol to achieve the desired shape of the canal system was a time-consuming process. It involved the tedious use of pre-curved files and reamers to follow the anatomical curvatures of the canal.

Other requirements that caused some controversy then (and still does), besides the size of the access opening, was the need to keep the apical foramen as small as possible, and to maintain patency throughout the entire process. The majority of more recently published research and clinical studies have confirmed the rational for an appropriate access and correct shaping.

In the early 1990s, technology brought about the introduction of rotary instruments, relieving the op-
The ProFile rotary bur (Tulsa Dental) with 0.04 and 0.06 taper, was introduced to the profession. Creating the shape necessary for the successful use of the warm obturation techniques was made easier and faster.

By the beginning of this century, numerous designs gradually evolved utilizing varying tapers, active or passive cutting blades, etc. (Fig. 1). At first, the biggest problem with the rotary files was breakage during use. But modern nickel titanium (NiTi) metallurgy technology has developed more, and more dependable, rotary files. As a result, today the separation of a rotary instrument during use is of virtually little or no concern.

It has also been shown that proper shape permits more thorough irrigation and the removal of significantly more debris from the prepared canal system. Disinfecting irrigation should be used between each instrument during the entire shaping process and patency continually maintained with a #10 file. Note: the quantity of irritants used is not as important as the frequency of use. The irrigation protocol, instruments, fluids, etc., are in constant evolution and becoming more effective. However, a clean and sterile environment of the canal system prior to obturation is still the objective.

Irrigation for cleaning the canal system

After shaping is completed, final cleaning can be effectively accomplished by the alternative use of:
1) Warm 3- to 6-percent NaOCl
2) 17 percent aqueous EDTA for approximately 30 seconds (smear layer removal)
3) Warm 3- to 6-percent NaOCl (further disinfect and stop action of the EDTA).

Fig. 6. When drying canals with air, needles must be notched or side-vented (arrows).

Fig. 7. The Chapman Huffman in-line air regulator and 0–15 psi gauge works well.

Fig. 8. Fresh absorbent points are used to remove excess sealer until ‘blotchy.’

Fig. 9. Only a very thin layer of sealer needs to coat the walls for lubrication. (Photo/Courtesy of Bob Sharp, Sacramento, Calif.)

roots
The NaOCl can be effectively warmed by placing the irrigating syringes in a beaker of water set on a small coffee warmer (Fig. 2). The canal(s) are completely flooded with the desired solution; an EndoActivator (Dentsply) is appropriately used for the “tsunami effect,” then re-irrigated with the same solution for flushing of debris (Fig. 3). The NaOCl is then effectively removed with a capillary tip (Ultradent) attached to a high-speed evacuator. Other solutions (hydrogen peroxide, chlorhexidine, 17 percent aqueous EDTA, MTAD, etc.) can also be used alternately, depending on operator preference.

Close observation with an SOM will clearly indicate complete cleaning of the canal system when no debris is flushed out during the irrigation process. During the evacuation with the capillary tip, it becomes apparent if there is a joining of the canal systems within the root. For example, if using the SOM as the MB1 canal is being evacuated and it is noted that fluid is simultaneously being drawn from the MB2 canal, there is a good indication that the system is complicated and does join at some point (Figs. 4a,b). There are occasions, especially in lower molars, where the mesial root canal system unexpectedly joins with the distal root canal system.

On occasion, the maxillary canal system will have the DB or MB canal system connected to the palatal system. These “surprises” are important to be aware of, before obturation of the canal system, especially when using either carriers or injectable GP.

_Drying canals with F•I•R•E_

The canal(s) are flooded with 95 percent ethanol (Everclear, available at local liquor store), agitation of the fluids are initiated with an activator for the tsunami effect, then re-irrigated with the 95 percent ethanol, and then evacuated with the capillary tip. The canal(s) are then best dried by using a Stropko Irrigator on a dedicated, air-only syringe (DCI), but if a three-way syringe is used, be sure to express all water from the line first (Fig. 5). Next, with a 27- or 30-gauge notched or side-vented needle (Monoject), fitted to the tip of the Stropko Irrigator and bent as necessary, to easily dry the canal system (Fig. 6). Important note: It is essential to regulate the air pressure to the syringe at 1 to 3 psi and use a side-vented or notched needle, to prevent any possibility of inadvertently forcing air through the apical foramen. This is easily achieved...
As dentists, we are accustomed to a "blast" of air while using the usual air/water syringe tip and high air pressure to the A/W syringes. With a properly regulated Stropko Irrigator fitted with an appropriate small gauge needle, only a "kiss" of air is necessary to create the flow necessary for thorough air drying of the canal. On occasion, one has to direct the air to a sensitive area on himself or herself to be sure the air is even flowing. Just watching the evaporation that occurs within the canal, while using the SOM, is enough to convince any operator that there is indeed a flow of air. There is enough physiologic back pressure of the apical environment (1.5 mm Hg) to prevent movement of the air past the terminus in the correctly shaped canal. In almost 20 years, with many different doctors using the Stropko Irrigator to "air dry" canals, the author has only heard of one unfavorable incident. In that one case, the doctor did not use a side-vented needle and did not regulate the air pressure to the air syringe.

To repeat, when the Stropko Irrigator is used with the properly regulated air pressure (1 to 3 psi) and the appropriate 27- to 30-gauge, side-vented/notched needle is used, there is no fear of forcing air into apical tissues.

**Sealer application**

To the SOM user, the ineffectiveness of drying the canal with a paper point is soon realized. It is also easy to observe how differently the Kerr Pulp Canal Sealer EWT (SybronEndo) acts when the canal is in fact dry, not just blotted. After blotting with a paper point, the sealer tends to act like a drop of oil when placed on the canal wall. But when the surface is dried, using alcohol and air as described above, the sealer readily spreads onto the canal wall, much like a coat of paint.

The complete dryness of the canal to the desired working length is checked with a clean absorbent point that fits to length. This also gives the operator an excellent chance to recheck the working length and dryness of the canal. Any sealer (Kerr EWT, Roth, AH Plus, etc.) can be used as long as the heat of the warm GP does not cause a "flash set." The end 3 mm of a sterile paper point is coated with the sealer of choice and placed into the canal to the working length.

The author uses Kerr Pulp Canal Sealer EWT, mixed per usual directions, but a little “on the thin side.” Using short, rapid apical-coronal movements, the walls of the canal are completely coated with sealer. The use of the SOM is a great aid for observing when the coating of the canal wall by the sealer is complete. Then, a sterile absorbent point is used, in the same manner, to remove any excess sealer that may remain.

Depending on the amount of sealer placed at the beginning, more than one absorbent point may be necessary to get the “blotchy appearance” on the final point (Fig. 8). Only a thin coat of sealer is necessary for lubrication, so very little remains on the walls of the canal (Fig. 9).

One of the most common mistakes, made at first, is using too much sealer. When this happens, the excess sealer will be extruded back into the chamber, or apically when the warm GP is placed. In some cases, the GP may be prevented from completing the desired "flow" apically. Typically, only one or two points are normally needed once the operator achieves proficiency at applying the correct amount of sealer to begin with. Thermoplastic GP techniques are not sealer-dependent and depend more on the sealer as a lubricant and facilitate the flow of the thermoplastic GP.
Important consideration between using injection or carrier-based obturation

Essentially, there is one very significant difference between the two techniques. The injection technique fills the canal system from the apical to the coronal, whereas the carrier-based techniques fill from coronal to the apical. This is important to take into account, especially in cases in which the operator does not want to fill the canal to the orifice or needs to control the “depth” of the fill.

A good example would be in the case of treatment of a perforation repair. Using injection, the “fill” can be accomplished rather easily, and both the sealer and GP can be confined apical to the perforation. MTA can then be added to the repair in a very controlled manner (Figs. 10a–c). When a post space is required, the GP can be injected to any level in the canal, but it is better to obturate the entire canal first, so unknown anatomy more coronally in the canal won’t be missed.

Injection of thermo-plasticized GP with a Calamus or Obtura

After using the Obtura for more than a decade for thermo-plasticized GP obturation, the author switched to the Calamus when it was introduced many years ago. After thousands of canals were obturated using both of them, several advantages were noted when comparing the two units (Table 1).

Both units are available as a single unit, or a dual unit combined with a thermal handpiece for convenience (Figs. 11a,b). The consistent flow of the Calamus unit does make the learning curve quicker and easier to master than the Obtura, because the relatively large muscle action of squeezing the trigger could vary from patient to patient, or day to day. The much
entire canal system filled at the final endodontic visit. Which one would you bet on for predictability?

Table 1. A comparison of thermo-plasticized GP obturation with Calamus vs. Obtura.

**Calamus**
1. Flow is consistent and can be preset
2. GP & needles in single packaging
3. Single needle use the norm
4. Barrier protection easy to place
5. Less patient discomfort upon injection
6. Easier to relate/teach proper use
7. Can easily be rotated for ergonomics
8. No hand fatigue during use
9. No patient response during obturation
10. Generally, very clean to use

**Obtura**
1. Flow dependent on operator’s “squeeze”
2. GP pellets delivered several in a box
3. Multiple needle use the norm
4. Barrier protection more involved
5. Patient often felt a “flash of warmth”
6. Proper “squeeze” a longer learning curve
7. Unit difficult to turn to different angle
8. Hand fatigue can occur
9. Patients often felt apical pressure
10. More time consuming to clean
while compacting, instead of giving the GP time to compact. Just a few seconds are needed for the newly compacted "wad" to cool.

**Obturation with carrier-based GP (Thermafil)**

Carrier-based GP (Thermafil) was first conceived by Dr. Ben Johnson of Tulsa, Okla., in 1975; published in 1978; and made commercially available to the dental profession in 1988 (Tulsa Dental). It has become one of the most popular and respected techniques in the world. Today there are many forms of the Thermafil concept on the market that conform to the design of various rotary burs (Dentsply Tulsa) (Fig. 13). The technique saves the operator a significant amount of time during the obturation process, and excellent results have been supported by numerous studies over the years.

After shaping, cleaning and disinfection is complete and the canal is still filled with fluid (NaOCl, CHOH, etc.), a NiTi verifier the same size as the maximum apical file (MAF) is selected. Using just the fingers, it is spun into the canal to working length. The verifier has to be passive when doing this step. Depending on the canal anatomy (straight vs. curved), if there is significant resistance with the selected verifier, such as traversing a curve of sufficient radius, then the carrier of the same size will meet the same resistance when it is placed. Therefore, you would then drop down one size, test-spin that verifier to length, and it should encounter less resistance. This then would be the correct size carrier to choose, regardless of what the final apical size was that you machined. Note: The verifier is not verifying the apical size of the preparation, but it is a dress rehearsal for how the carrier is going to behave when it is inserted into the space. It is verifying the ease of insertion of the eventual carrier core.

For example, if you instrumented to a MAF size 30/0.06 in a significantly curved canal (less than 25 degrees), a #30 size verifier may not spin easily to length; you would try a #25 size verifier instead. In all likelihood, the #25 will go to length without significant resistance.

The resistance it encounters is a function of the file/carrier being distorted by the curvature of the canal space; the greater the curvature, the greater the distortion and resistance (and the greater the chance of contacting the carrier on two opposing sides during insertion, possibly stripping the GP from the core). Dropping down one size eases that impingement without compromising the carrier’s ability to transport the softened gutta-percha to length. The use of the size verifier is critical to the successful placement of the eventual carrier, but is often done improperly, or not at all.

Once the appropriate carriers are chosen, the canal spaces are dried completely with paper points, the "FIRE technique," etc. A small amount of sealer is applied to the canal walls with a paper point (pin-head drop) into the shaped canal. If the canal is not dry, the excess moisture will prematurely cool the advancing wave of GP, resulting in a "pig-tail" of GP extruded into the PA area. The same will occur with excess sealer, and it will extrude along with the GP.

The carriers are placed singly into the oven, the correct time chosen, and the cores allowed to heat to the proper temperature. The small plastic, and all Gutta-Core carriers, are heated on the first setting (20 to 22 seconds); size 30 to 60 Thermafil Plus heated with the second setting (40 to 42 seconds); and size 70 or larger, the third setting (44 to 46 seconds). The carriers can be reheated, if necessary, and the time setting for the larger carriers is not critical, as long as they are heated for at least 40 seconds.

Insertion of the heated carrier is slow and deliberate; you need to allow the excess material to be vented coronally. Insertion rates are 2 to 3 mm per second, which would translate to an average time of seven to 10 seconds for most canals from orifice to working length. With the larger carriers, you may experience a "rebound" effect after the carrier is inserted a few millimeters into the canal. Release the carrier and it will "rise" slightly from the canal space. This is the GP venting and pushing the carrier back out of the canal slightly as it vents. Once the rebound is stopped, you can continue the insertion, stopping every few millimeters to check for rebound until the carrier is inserted to length. Pushing through the...
The FibreKor posts have a wide selection of posts with good retention and are easy to use.

Fig. 20

Diameter Sizes:

- 1.50mm
- 1.375mm
- 1.25mm
- 1.00mm
- 1.125mm

Beyond the apical terminus. Many endodontic failures were blamed on vertical over-extension, but in reality the culprit was an "under-filled" canal system. As Schilder stated, "You can only fill a canal 100 percent." If the canal is filled 100 percent, any excess material extruded would be of no consequence. In fact, if the author obturated a canal system and there was no excess filling material, the GP would be routinely removed and re-obturated until there was. The point was, "How else could you be sure the canal system was obturated 100 percent unless there was some excess filling material present at the apex?"

Cases that have a significant amount of excess filling material but are properly shaped, cleaned and packed do heal. Over time, the excess material will slowly be resorbed (Figs. 16a,b).

The biggest fear of the new user of injection or carrier-based GP is, "There will be a great amount of excess filling material at the terminus." The opposite is generally true. At first, the most common problem for the new user was the inability to get to the terminus and completely fill/obturate the canal system. The usual reason for this was either an improper shape, the absence of patency or fear of the operator to use enough pressure during the injection and compaction process.

A good way to imagine what is happening, while using thermo-plasticized GP in a properly shaped and patent canal, is to envision everyone in a theater rushing to get out the same door in a big hurry. The GP molecules are relatively large and warm, so the continually tapering shape is, in itself, a limiting factor for the amount of sealer, or filling material, that will be extruded beyond the apex.

If the apical terminus of the canal is kept as small as practical, about the size of a 20KF, it is hard to obtain more than a small "puff" at the apex, no matter how hard the operator compacts the thermo-plasticized GP (Figs. 17a,b). However, it makes sense that the larger the apical opening, the larger the amount of excess material might be extruded. In a short period the operator develops the necessary "feel" to be very predictable with the obturation and compaction process.

This is the essence of the learning curve when beginning to use a thermo-plasticized technique. Also, since the softness of thermo-plasticized GP is maintained for a longer time in a larger mass size (volume), the apical extent is the first to become solid since it has the smallest volume of mass. These techniques are easy, fast and predictable for achieving excellent obturation, if all is done as described.

Excess filling material

Historically, any time a case was obturated, there was much concern when anything was extruded and rebound and not allowing the GP to vent coronally will precipitate significant extrusions.

Depending on which type of carrier is used, the handle is cut at the orifice level using either a Prepi bur, or a thermal tip (Figs. 14a,b). Removal of the handle is essential when placing more than one carrier in the access, as multiple handles in the access will obscure the view for the succeeding placements. A radiograph is taken to confirm placement, and any adjustments are easily made by engaging the core with a file and removing from the canal. Using a high-speed round bur, the remaining carrier "stubs" are trimmed to the desired level. If a post space is desired, it can be prepared immediately with an end-cutting ProPost drill (Dentsply) that will not displace the carrier.

Compaction of warm GP using Thermafil for carrier-based obturation is slightly different. A simple technique is to segment a GP cone into approximately 5 mm sections prior to the obturation process. Immediately after the Thermafil carrier is separated with a Prepi bur (Dentsply), the GP at the orifice is still soft and can be readily compacted. To facilitate thorough adaptation, a small and lubricated plugger (about a size 8 to 8.5 Schilder) can be used to apically compact the warm GP alongside the carrier.

Push apically to a predetermined distance, hold briefly and remove the plugger. Then, using one of the pre-cut segments of GP, place it into the void created by the plugger, and compact it into place. More segments of GP may be necessary depending on the size of the canal. In cases when the canal may be ribbon-shaped and large in the M-D or B-L direction, the apical third of the canal is obturated in the conventional manner. Then an accessory carrier can be inserted alongside the initial carrier (Fig. 15).

The second core of the second carrier functions as a gentle spreader to assist in the lateral compaction and spread of the softened GP. The warm GP from the first and second carriers fuse together so any voids are eliminated.

Now for the rest of the seal

The final step of the System "S" protocol is to fill the entire canal system. It is self-defeating to do a beautiful job in the apical half of the canal system and turn the case over to another person to complete
the coronal half of the obturation. As endodontists, we are generally concerned with "the fill" and forget the importance of sealing "the rest of the system." To illustrate this concept, look at the four cases depicted in Figure 18, and then decide which one would have the most predictable chance of success. They all have well-done endodontic treatment, but only one case has had the entire canal system sealed.

A survey taken not too long ago showed that 95 percent of general/restorative dentists did not use a rubber dam while placing a foundation restoration in an endodontically treated tooth. To maximize the predictability of success and avoid possible post-op complications, the "endo-doer" must be responsible for the seal of the entire canal system. Here are just a few reasons to do the foundation restoration at the same visit:

1) Patient is "in the chair."
2) Patient is anesthetized.
3) Rubber dam is in place.
4) Access is sterile for placement of the foundation restoration.
5) All previous restorative materials are easily removed.
6) The "endo-doer" has microscopically enhanced vision.
7) The "endo-doer" knows correct angle, size and depth of the canal system.
8) There is no chance of contamination of the canal system.
9) Inadvertent perforations are eliminated.
10) The tooth can be "roughed prepped" with dam in place.
11) The patient has more time to plan for the final restoration.
12) After RCT, doctor knows, within two minutes, the time to schedule for crown prep.
13) On anterior teeth, appointments can be coordinated for placement of a provisional.

It has been shown that coronal leakage is the major cause of root canal treatment failure. Therefore, it behooves us to do all that is possible to prevent it. If multiple visits are required, the doctor should not rely on "cotton and Cavit" to maintain sterility. With the current bonding and composite technology, the temporary placed between visits should be a bonded composite.

A good example of an easy-to-use temporary is auto-cure Tenure Uni-Bond and Core Paste (Denmat). CaOH (Ultracal by Ultradent) is injected into the canal system and covered with a sterile cotton pellet (Fig. 19a). Then Tenure Uni-Bond is used to condition the access opening (Fig. 19b). After just a few minutes, the auto-cure Core Paste is set completely, the occlusion is ready for any adjustments, to make sure there are no interferences left to irritate the tooth between visits.

On occasion, a patient is unable to keep the ap-pointed return visit and may have to delay his or her return visit for weeks or months (Fig. 19c). There may be an important change of events in his or her life, or the doctor may also have to change the scheduled visit. If a temporary is placed, such as Cavit, IRM or Tempit, all control of the bacterial environment in the canal system is lost in a relatively short period if the patient does not return in a timely fashion.

Who would be better to control the coronal aspect of the tooth following endodontic obturation than the "endo-doer," while the case isolated with a rubber dam in place? As Dr. Denny Southard of Tulsa, Okla., commented almost 15 years ago, "When we slap in Cavit and turn our heads, the case is destined for contamination or worse [perforation, for example]." However, if a more definitive seal is maintained, that part of the equation becomes a non-issue.

An easy foundation restoration technique

After the obturation of all canals, the gutta-percha is removed to the proper depth in the orifice as required for retention. This is quickly and easily done using a Munce Bur at approximately 5,000 rpm. If a post space is required using carrier-based GP, a ProPost drill can be used to remove a little GP at a time, until the desired depth is reached. Using the co-observer tube of the SOM and a precise flow of air from the Stropko Irrigator, the chairside assistant can aid in the removal of all bits of sealer and GP to maintain vision while final cleaning of the access/post space is done.

After the mechanical cleansing of the access is accomplished, it is flooded with 95 percent ethanol to remove any remaining sealer and scrubbed with a
micro-applicator (SybronEndo). Another application may be necessary to achieve a clean surface. If there is a post space, it can be cleaned the same way, but after flooding the space with 95 percent ethanol, use a Versa-brush (Vista) turning at approximately 500 rpm to be assured of getting the post space walls free of sealer. After this step, the post used can be tried in to be sure it fits passively.

The FibreKor post kit (Pentron) has a very good selection of sizes (Fig. 20). The 1.125 mm (lavender colored lid on tube) fits most of the post spaces passively. If the fit of the post is not passive but is the desired size, a very fine, tapered diamond is used to taper the apical end until it does fit passively into the space. Note: A post space should never be enlarged to fit the post. The post should always be adjusted to fit the post space. A post should only be used for retention of the core buildup and does not strengthen the tooth.

Rinse and dry the access, and then flood it with 37 percent phosphoric acid gel (Ultradent), letting it remain for approximately 20 seconds to accomplish the proper etch of the walls. Rinse very thoroughly and air dry, being careful not to desiccate the dentinal surface. Apply two coats of Tenure A&B (DenMat) for conditioning of the dentin, air drying between each and inject Core Paste (DenMat) to fill the access completely. If needed, the FibreKor post can be cemented with the initial application of Core Paste.

It is a good idea to also coat the fiber post with the Tenure A&B before insertion into the newly injected, soft Core Paste. Note: Do not use the Tenure Uni-Bond for this step, as it is thicker in consistency and may affect the passive fit of the post.

Core Paste is one of the most forgiving and easy-to-use materials. It is auto-cure, has adequate working time and can be “stacked” or added onto, so enough bulk is easy to achieve for the desired buildup, and it always sets up in two to three minutes. The tooth can then be rough prepped and returned to the referring doctor (Figs. 21a–c). At any rate, the endodontically treated tooth is ready for the final crown prep and impression if the doctor wishes to do it at the same appointment.

Respect for the endo-pros relationship

Current technology has allowed endodontic treatment to achieve a very high degree of success when the coronal seal has been accomplished. Wein has stated that more endodontically treated teeth are lost due to improper restoration than to endodontic failure. More recently, it was shown that in 1.5 million people over an eight-year period, there was a 97 percent success rate for endodontically treated teeth. Of the 3 percent that failed, 85 percent of those had no coronal coverage. It is necessary to appreciate some basic restorative/prosthodontic principles to establish a degree of predictability we want to achieve with the System “S” protocol of treatment.

It has been shown that teeth do flex during normal function. The less radicular structure present, the weaker the tooth will be. And the weaker the tooth, the more it flexes. The more it flexes, the more micro leakage occurs, and it becomes only a matter of time before the tooth fails. The canal system can be contaminated due to micro leakage, by fracture due to lack of radicular strength, or the crown/post/core can break or come out. If a restoration is placed, entirely based on the retention of the foundation restoration, it is not an issue of whether the restoration will fail; it is a matter of when it will fail.

It is critical that a minimal circumferential ferrule of 1 to 2 mm be established for retention of the restoration. A biological width of approximately 2 to 3 mm is required between the osseous crest and the cervical margin of the restoration. Therefore, a minimum total of 3.5 mm is necessary between the intended cervical margin of the restoration and the osseous crest.

Another important consideration for conserving root structure is the necessity of a post for retention. It is worth repeating, “A post is only indicated if retention of the core is inadequate without it. Posts are only indicated when needed for retention. The post space must never be shaped to fit the post. Instead, the post must be shaped to fit the existing post space.” The more radicular substance removed, the weaker the tooth. Posts never strengthen a tooth.

Conservation of the radicular structure also needs to be considered when accessing and shaping the canal system. Only enough tooth substance should be removed to achieve vision and desired shape needed to completely disinfect, clean and obturate the entire canal system. If the access is compromised, the correct shape may be difficult if not impossible to achieve. Likewise, if we compromise the shape, the cleaning and obturation will also not be as complete as desired for predictability. The author is amused by anyone willing to compromise access and shaping in the name of tooth conservation. What good does all that tooth structure do if the tooth is lost to disease?

Once the referring doctors are made aware of the favorable benefits that will be derived, it becomes difficult for a conscientious person to object to this concept of eliminating untoward possibilities that can lead to failure of treatment.

Conclusion

The System “S” protocol demands thoroughness in treatment of the entire canal system. The author uses a Calamus for obturation, but carrier-based techniques of using warm GP can be used with the same degree of success, as long as they are done correctly. System “S” requires a commitment to
complete all six steps to avoid the many pitfalls that present themselves during treatment of the entire endodontic canal system.

A survey of endodontists taken about nine years ago stated that 38 percent always used an SOM, 30 percent sometimes used it, and 32 percent never used it.11 Hopefully, things have changed. The use of an SOM is essential for us, as “endo-doers,” to achieve the high level of predictability our current technology allows us to deliver. We only know what we see, and if we don’t see it we don’t know it. A good example is the high percentage of fourth canals (93 percent) that can be found in the maxillary molar segment. The clinical use of the SOM significantly increased the number of canals that were discovered.12 If these canals are not found, and the operator doesn’t take the time to locate and treat them, the predictability of success will be far less. It behooves all of us to do everything humanly possible to give our patients dental treatment that will create the health they expect from our profession.

In general, our current endodontic vision has been directed to treatment of the apical half of the root canal system. It should not be a problem integrating the basic principles of bonding technology, restorative principles and post core placement into our normal endodontic treatment protocol. We, as a specialty, should be thinking in terms of being responsible for the entire canal system and doing everything humanly possible to increase the predictability of our treatment. When endodontic treatment fails, it seems like everyone “stands around in a circle and points at one another.” Adhering to proven principles eliminates the probability of contamination of the canal system by providing a solid foundation for the restorative aspect of the patient treatment.

Obviously, those who are so concerned with the endodontic lack of respect for radicular structure have not witnessed what often happens to that same tooth when preparing it for a crown. It is imperative for the entire canal system and doing everything humanly possible to increase the predictability of our treatment. When endodontic treatment fails, it is humanly possible to increase the predictability of our treatment.

In general, our current endodontic vision has been directed to treatment of the apical half of the root canal system. It should not be a problem integrating the basic principles of bonding technology, restorative principles and post core placement into our normal endodontic treatment protocol. We, as a specialty, should be thinking in terms of being responsible for the entire canal system and doing everything humanly possible to increase the predictability of our treatment. When endodontic treatment fails, it is humanly possible to increase the predictability of our treatment.

Our job as “endo-doers” is to learn, become teachers and educators to the patients, staff and doctors we work with, so we can achieve dental health as a team. Let’s not “cave into” the demands of public convenience or political pressure, but rather be governed by proven dental principles, so we can achieve predictable endodontic success, saving the teeth our patients are born with. Isn’t that what endodontics is all about?

References


About the Author

John J. Stropko received his DDS from Indiana University in 1964. For 24 years he practiced restorative dentistry. In 1989 he received a certificate for endodontics from Boston University and has recently retired from the private practice of endodontics in Scottsdale, Ariz. Stropko is an internationally recognized authority on microendodontics and has performed numerous live microendodontic and microsurgical demonstrations. He has been a visiting clinical instructor at the Pacific Endodontic Research Foundation (PERF); an adjunct assistant professor at Boston University; an assistant professor of graduate clinical endodontics at Loma Linda University; a member of the endodontic faculty at the Scottsdale Center for Dentistry in Scottsdale, Ariz., as an instructor of microsurgery; and is a co-founder of Clinical Endodontic Seminars. His research on in-vivo root canal morphology has been published in the Journal of Endodontics. He is the inventor of the Stropko Irrigator, has published in several journals and texts and is an internationally known speaker. Stropko and his wife, Barbara, currently reside in Prescott, Ariz. You may contact him at docstropko@gmail.com.
Opinions vary as to the best means to achieve three dimensional cleansing, shaping and obturation of the root canal system. Emerging technology, literature research and proven clinical success all provide clinicians with options, evidence and methods for their clinical techniques. Presently, there is no commercial consensus on the optimal methods for canal preparation, especially when considered across the wide range of clinical cases encountered. The options in the marketplace are myriad — Dentsply, Coltene Whaledent, SpecializedEndo, Brasseler, Ultradent.

Taking into account the present state of the art in nickel-titanium science and manufacture, literature evidence and extensive clinical experience, what follows are the author’s chosen materials and methods of shaping root canal systems, i.e., the MounceFile. This article was written both to introduce the MounceFile and suggest that the reader compare his or her present systems and treatment strategies for achieving the goals of canal preparation.

The goals of canal preparation are to:

• Maintain the original position of the canal.
• Maintain the original position and size of the apical foramen.
• Prepare a tapering funnel with narrowing cross-sectional diameters (in essence, to mimic the shape of a tornado).
• Prepare a taper that is proportional to the external dimensions of the root that does not predispose the root to subsequent vertical fracture.
• Prepare a taper that allows cone fit with tug-back and ideal obturation hydraulics during down pack with warm vertical obturation techniques (and warm techniques of all types).
• Prepare a taper that optimizes the necessary volume and space for activation of irrigants.

Among other valid and clinically proven marketplace choices, MounceFiles represent a literature-based, clinically valid, safe, efficient and economical option for canal preparation.

Universal application

It is a personal bias that not every instrumentation system is applicable to all canal anatomy encountered. Anatomy is infinite in its diversity (three-rooted lower molars, etc.), variety (length, curvature, etc.), clinical challenge (resorption, immature apices, etc.) and the environment in which these canals are treated (limited opening, etc.).
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MounceFiles come in two forms of nickel titanium, Controlled Memory© (CM) and standard nickel titanium (SNT). CM nickel-titanium files result from a proprietary thermomechanical treatment of nickel-titanium whereby once curved, the files remain curved. Clinically, this means that as a CM instrument rotates through a curvature, the file remains curved, a valuable attribute in a complex canal. SNT files are superelastic, meaning they spring back to their original shape after being stressed (used clinically). CM instruments have shown increased resistance to cyclic fatigue and other attributes relative to their superelastic counterparts.1–5

MounceFiles are square in cross section, non-landed and of constant taper throughout their cutting flutes. The square cross-section provides added fracture resistance relative to triangular cross sections due to the increased metal mass in this dimension.

MounceFiles are square in cross section, non-landed and of constant taper throughout their cutting flutes. The square cross-section provides added fracture resistance relative to triangular cross sections due to the increased metal mass in this dimension.

The MounceFile Assorted Pack is designed more for the general dentist and the typical endodontic case. Specifically, this pack is ideal for teeth that are 18–23 mm, have roots of moderate curvature and canals that are located with relative ease and negotiable with hand files. The MounceFile CM Assorted Pack and MounceFile SNT Assorted Pack are configured (from left to right in the box) from larger tapers to smaller: .08/25; .06/25; .04/25; .03/25; .02/25; .03/30 (Fig. 1).

The MounceFile system was developed to give endodontists a virtually unlimited choice of tapers and tip sizes to custom assemble their file configurations and handle virtually any clinical case. If the endodontist (or general dentist handling complex cases) wants to customize his or her selection of MounceFiles, there are 75 combinations of taper and tip size available in both CM and SNT files. Tapers include .01 in addition to the tapers present in the assorted packs. Tip sizes among the tapers range from 20–60, depending on the taper.

The breadth of this product line gives an unlimited set of options for clinicians of any experience level (from dental school graduates to veteran endodontists) to treat virtually any canal (from a straightforward #8 to a more complex 25 mm C shaped #18 with multiply-nar curvature and a relatively open apex in proximity to the inferior alveolar nerve).

Clinical technique

The following directions for use and FAQs have been adapted from PDFs on the www.MounceEndo.com website. These directions reference the MounceFile CM Assorted Pack. The directions for the MounceFile SNT Assorted Pack are identical to those below.

Specifically, the MounceFile CM Assorted Pack is used within the context of the following treatment steps:

Step No. 1: Estimate the true working length
Before making access, the clinician should estimate the true working length (TWL) from the initial preoperative radiographs. This is the estimated working length (EWL). The EWL is used later to help confirm the TWL, which is determined radiographically or electronically (Foramatron-Parkell, Elements Diagnostic Unit-Axis/Sybron, Root ZX II-J Morita).

Step No. 2: Prepare straight-line access
Straight-line access is achieved when all of the canals can be seen in one mirror view and hand and rotary files can be inserted without deflection off the axial walls of the preparation.

Step No. 3: Remove the cervical dentinal triangle
The .08/25 MounceFile CM is inserted 2–3 mm below the orifice and removed with a brushing motion up
and away from the furcation (against the canal wall of greatest thickness). After removal of the CDT, the pulp chamber and canal orifice is irrigated copiously.

**Step No. 4: Shape the coronal third**

After CDT removal, using light pressure, the .08/25 MounceFile CM is gently inserted to the point of first canal curvature. Insertion is gentle and should ideally take about three seconds. The file is not used with a pecking motion. If the file will advance easily and shape the coronal third or advance to the point of first curvature, then it can be taken to this level.

If the .08/25 MounceFile CM file will not easily reach the point of first curvature (or shape the coronal third) after several insertions, do not force the file to reach length. Move to Step No. 5. Irrigate copiously after every insertion of the orifice opener.

**Step No. 5: Establish and/or confirm apical patency**

Stainless-steel K files are used to establish and/or confirm apical patency (Mani K files, Mani D Finders, Mani Flexile K files). Using the EWL determined from the pre-operative radiographs, pre-curved hand K files (#6, #8, #10; whatever size is appropriate to the canal treated) are inserted successively until the EWL is reached. Now the clinician should verify he or she has reached the apex of the root with an electronic apex locator and/or a radiograph. The EWL and the TWL should be relatively close if not identical.

**Step No. 6: Prepare a glide path**

Once a hand file reaches the apex and TWL is established, the canal should be enlarged to the diameter of a #20 hand file, i.e., prepare a glide path. One proven method to prepare a glide path is with #6, #8, #10, #15 and #20 hand K files used in succession. A reciprocating handpiece can be immensely helpful in preparing a glide path, especially using a safe-ended hand K file (Mani SEC O K file) (Figs. 2a–d).

**Step No. 7: Prepare the canal ‘crown down’**

The .06/25, .04/25, .03/25, .02/25, .03/30 files are used successively until the desired taper and tip size is achieved. In the majority of clinical cases, a .06 taper is prepared to the apex (i.e., to the TWL). Using the MounceFile CM Assorted Pack, this means the .06/25 instrument will be taken to the TWL before preparation of the master apical diameter.

If any given file in the MounceFile CM Assorted Pack does not advance apically without undue pressure, move to the next smaller file in the sequence (from left to right in the pack, i.e., crown down) and continue to use them in succession (from larger tapers to smaller) until the desired taper is prepared to the apex.

As with the .08/25 MounceFile CM file, the insertion should be gentle, to resistance and take approximately three seconds. Such file engagement should remove approximately 4–6 mm of dentin with each insertion. Do not use a pecking motion or force the files apically. After each insertion, irrigate the canal and recapitulate with a small (#8, for example) hand K file to assure patency (Figs 3a, b).

**Step No. 8: Prepare the master apical diameter**

Once the final taper is prepared (generally .06 taper), the .03/30 MounceFile CM file is taken to the TWL to prepare the master apical diameter (MAD). If the clinician
wishes to prepare a larger MAD, he or she can do so by whatever means is desired.

_Important Supplementary Information_

- Use an electric torque control endodontic motor (TCM III-Axis/Sybron).
- 500 rpm is recommended. Rotational speed can be modified depending on clinician experience and preference from 500-900 rpm.
- A gentle and feather touch insertion of the file is recommended. Insertion should seek to minimize engagement of the instrument to 4-6 mm of canal wall per insertion, which generally will take about three seconds. Files should be rotating when inserted. Files should be inserted or removed but never left stationary while in use. Do not use a pecking motion or insert the file repeatedly in order to progress apically. If the canal resists apical advancement while using minimal pressure, remove the instrument and choose the next smaller file.
- After insertion, the flutes are wiped of debris, the canal irrigated and the canal recapitulated with a small hand K file (Mani K file #8 or #10).
- To minimize risk of canal transportation and/or file separation, each file should be taken to the true working length only once for one to two seconds, then removed.
- Irrigation and recapitulation should be performed after every insertion.
- If the file is inserted as per the instructions above, using torque control with the auto reverse function engaged is a matter of clinician preference.
- Single use is recommended.
- Discard files in an appropriate biohazard sharps container.
- Straight-line access and removal of the cervical dentinal triangle are recommended.
- While a step-back approach to instrumentation is feasible and possible in many canal anatomies, the MounceFile CM and SNT instruments are used most efficiently in a “crown down” (CD) sequence, shaping the coronal third first, middle third second and apical third last. Clinically, this means that larger taper and tip-sized instruments are used first followed by smaller.
- Rubber stopper colors on the MounceFiles indicate taper size: .01 Purple, .02 White, .03 Black, .04 Red, .06 Yellow, .08 Light Blue.
- The .08/25 mm orifice opener in the 21 and 25 mm MounceFile CM and MounceFile SNT Assorted Packs is 21 mm long.
- No set of instructions or precautions is comprehensive. Evaluation of risks is essential. Treatment algorithms and clinical strategies must often be revised in the face of anatomical challenges (severe calcification, curvature, open apices, etc.). Clinical judgment and caution are advised.

_FAQs_

**What is “Controlled Memory” (CM) and how do these files differ from standard nickel-titanium files?**

Controlled Memory instruments have been subjected to a proprietary thermomechanical treatment that provides significant resistance to cyclic fatigue relative to nickel-titanium (NT) instruments without this treatment. When a CM instrument curves during treatment, it retains its shape. CM treatment reduces the effects of NT shape memory, minimizing transportation. Use of CM instruments versus the MounceFile SNT (standard nickel titanium) files is a matter of personal preference with the limitation that SNT instruments are less resistant to cyclic fatigue relative to the CM variety.

**How many times can I use the MounceFile CM and SNT files?**

Single use of the MounceFile CM and SNT instruments is recommended.

**How do I sterilize new packs of files?**

With a steam autoclave, sterilize the instruments at 136 degrees C for 20 minutes.

**Can I use MounceFile CM and SNT files to remove gutta-percha?**

Yes, appropriately sized MounceFile CM and SNT files can be used to remove gutta-percha in retreatment.

**Is torque control recommended?**

If the file is inserted as per the instructions below,
Diamonds have taught us to appreciate the importance of lasting value.

Diamond burs are just a part of the Komet® product range, but they remind us of what is really important: lasting value. Each of our products – whatever the material or application – is designed to give you that little bit extra: extra durability, extra stability, and extra precision. That’s what makes a product worthy of the name Komet®.
using torque control with the auto reverse function engaged is a matter of clinician preference.

Why is the .03/30 MounceFile CM instrument at the end of the sequence?

The .03/30 MounceFile CM instrument (at the far right of file box) allows the clinician to prepare the apical diameter to a #30 tip size.

How do I obturate a canal prepared by the MounceFile CM Assorted Pack?

Canals can be obturated in whatever manner the clinician chooses. Using vertical compaction and lateral condensation techniques, it is efficient to learn to trim cones. Specifically, a .06/25 cone trimmed 1 mm from its tip is approximately equivalent to a #30 ISO instrument. If the clinician is using carrier-based obturation, he or she can use a size verifier and place the carrier as desired.

What if I want to prepare a larger apical diameter than a #30 tip size?

The clinician can use whatever means he or she desires to prepare an apical diameter larger than a #30. In the MounceFile CM file system, the .03-tapered instrument is available (among other tip sizes) in a #40 tip size.

What is “crown down” instrumentation and what are the advantages of this approach in canal shaping?

After straight-line access is prepared, the orifice shaped, the canals negotiated to the apical foramen and a glide path prepared, crown down instrumentation means that the coronal third is prepared first, the middle third second and the apical third last. In essence, the clinician is preparing the root from the crown of the tooth to the root apex, so crown down (CD).

The advantages of CD instrumentation outweigh any relative disadvantages. A CD approach removes restrictive dentin, especially in the coronal third, and facilitates its removal by allowing early and copious irrigation prior to enlargement of the middle and apical thirds. Removal of restrictive dentin and its evacuation from the root minimizes the possibility that this debris will be pushed apically. Alternatively, leaving this debris risks canal blockage, an outcome correlated with uncleaned and unfilled canal space and canal transportation.

Are there any contraindications to crown down instrumentation?

There are no absolute contraindications to the CD technique. There are several clinical situations where a CD approach might be less efficient. Specifically, cases of severe curvature, with or without severe calcification, might argue for a step back (SB) approach or a combination CD and SB approach. Such severe cases are not what the MounceFile CM Assorted Pack were designed to treat and these cases generally require a combination of specialized techniques (Figs. 4, 5).

What pre-operative considerations are correlated with endodontic success (among other factors)?

- Optimal visualization (ideally a surgical operating microscope, most certainly loupes, Global Surgical, Zeiss, Orascoptic).
- Copious irrigation.
- Use of the rubber dam for every case, without exception.
- Use of a bite block where possible.
- Profoundanesthesia (STA-Milestone Scientific).
- Pre-operative assessment of risks (number of roots, curvature, calcification, risk of perforation, open apices, presence of root resorption, etc.)
- Diagnostic radiographs (taken from different angles) and a cone beam where indicated to fully illustrate the anatomy (Planmeca, Sirona).
- Referral when in the best interest of the patient.
- Staff training and education (if the staff knows what each step of the treatment process is intended to accomplish, they can provide the needed support more efficiently).
- Having the needed instruments available in the sizes required and having them organized in a fashion that makes them easy to access and store while not in use.
- Detailed informed consent.

This clinical article has introduced the MounceFiles, a new, literature-based, clinically valid, safe, economical and efficient rotary nickel-titanium option for canal preparation. Emphasis has been placed on blending proven clinical principles with the instruments discussed. Readers are encouraged to compare their present systems and treatment strategies to those presented here. I welcome your feedback.

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

Rich Mounce, DDS, is in full-time endodontic practice in Rapid City, S.D. He has lectured and written globally in the specialty. He owns MounceEndo LLC, marketing the rotary nickel-titanium MounceFile in Controlled Memory and Standard NiTi. MounceEndo is an authorized dealer of Mani stainless-steel hand files and burs. Mounce can be reached at richardmounce@mounceendo.com, www.mounceendo.com and on Twitter at @MounceEndo.

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No more supremely stinky teeth

Author L. Stephen Buchanan, DDS, FICD, FACD

Extracted human teeth have been a blessing and a curse for endodontic educators. The blessing? Teaching dental students and dentists new endo techniques in real human teeth without the human attached. Awesome, no human! The curse? Infected, supremely stinky teeth with unknown anatomy, no relationship to educational objectives, and no mulligans.

Let’s put aside the supremely stinky teeth part for now and just look at the unknown anatomy issue, the educational objectives issue, the testing issue and the no mulligans issue.

The unknown anatomy issue doesn’t need much explanation. Unknown anatomy is the fun part of clinical endodontic practice, but it’s a nightmare in procedural endodontic training. Think about it. Teaching endo technique is limited by the random nature of the root canal anatomy presented in the extracted teeth students procure. It’s not like you get to choose the anatomic challenges that your students work their way through, or ever know what’s in those teeth they brought to your course.

The educational objectives issue is very simple. There are a number of procedural endodontic challenges — abrupt apical curves, “S” curves, cervical curves, mid-root bifurcations, apical confluencies, etc. How do you find a number of extracted teeth with the same anatomic challenge you want to teach your students to handle? Not possible with extracted teeth; they aren’t designed to answer a specific procedural training objective.

The testing issue? Extracted teeth for board exams are neither fair to the examined nor defendable as fair by examiners. No consistency, no defense, case closed.

The no mulligans issue? Being denied another attempt after you’ve just screwed the pooch working through a given anatomic challenge? That’s rough, and that’s why becoming competent in endo therapy has been a random walk through endo anatomy only overcome by a large number of cases treated.

Up until now, endodontic procedural training has been hamstrung by the random nature of the anatomy encountered by students when working in extracted teeth (not to mention the smell). When we attempt a procedure in a given root canal space and, for instance, come upon an impediment in the canal

Fig. 1 TrueTooth procedural training replica. Note the fine detail of internal root canal anatomy, including fins, webs, and loops, lateral and accessory canals — the full Monty. (Photo/Provided by Dr. L. Stephen Buchanan)
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but ledge it before we know better, we don’t get a second attempt. We are left to hopefully deconstruct the error correctly, and then just wait for another tooth having similar anatomy.

So what would it be like to repeat — in exactly the same anatomic form — a procedure over and over (and over, if necessary), until you get it?

Flash back to more than 20 years ago …

I treat a physics professor from UCSB who explains how he invented a method to print, in three dimensions, any computer-generated CAD model — a process he called Stereo-lithography. The machine he invented had a 10-inch cubed vat — with a plate that moved up and down in it — filled with photopolymerizing resin. Above that a laser traces the surface of the solution, polymerizing, layer-by-layer, the cross-sectional geometry of the object to be fabricated. The plate then drops by a precise amount, and the laser traces the next layer. When the object has been completely printed, the plate rises out of the resin bath with the object revealed.

This blew my mind completely. Everything was different now. Research, prototyping, testing, training, manufacturing, engineering, product design and pretty much everything else was, or was going to be, different now. My first question?

Could we print replicas of teeth?

I had spent the previous five years working out how to CT scan extracted teeth and reconstruct them in 3D computer space as virtual replicas,1 so replicating, in 3D, the incredible anatomy we were seeing in our reconstructed models was very fun to consider.

He said no, not yet — the technology was in early development so the resolution was too large to work for RCT training and the cost of printing at that point could only be borne by aerospace firms. So I waited for 10 years, and had a tooth replica printed at the resolution possible at that time but found it was not yet ready for prime time in dentistry (Fig. 1). Last year, the inflection points of resolution, polymer chemistry and cost intersected for dentistry’s use of stereo-lithography, and this year Dental Education Laboratories, after completing our development, introduced as TrueTooth™ training replicas.

It’s here now

These replicas are printed in clear and opaque versions for training and testing, and the polymers used are heat-resistant so high speed burs don’t gum up when cutting access cavities and the replica’s canal walls don’t melt when obturating with warm gutta-percha methods. Inside the replicas, in all the root canal spaces, is a gel-like material that is red in color and dissolves in sodium hypochlorite, immediately showing students the efficacy of their irrigation procedures. Inside the replicas, are the phenomenal intricacies of endodontic anatomy in all of its natural glory.

Negotiating through the canals gives tactile feedback that there is still “pulp” medium present, that the file tip has engaged a lateral fin or accessory canal — in other words, almost as good as the real thing. Cutting shapes in clear TrueTooth roots reveals what aggressive file tips are actually doing when they destroy apical anatomy during preparation procedures. Obturation procedures in these replicas are a “thrill of the fill” experience.

Summary? All boxes are ticked:

1) No unknown anatomy. All the anatomy of every replica is known.
2) Replicas can be chosen for teaching specific endodontic procedural skills.
3) Replicas are exactly the same so they are a fair test between board applicants.
4) 3D printed replicas can be worked with — over and over — the same challenge every time.
5) They are less expensive than the oversimplified training models available.
6) No more stinky teeth.

Endodontic procedural training will never be the same._

Reference


-about the author-

L. Stephen Buchanan, DDS, FICD, FACD, was valedictorian of his class at the University of the Pacific School of Dentistry, and he completed the endodontic graduate program at Temple University in Philadelphia in 1980. He began pursuing 3-D anatomy research early in his career, and in 1986 he became the first person in dentistry to use micro CT technology to show the intricacies of root structure. In 1989 he established Dental Education Laboratories, through which he has lectured and conducted participation courses around the world. Buchanan holds a number of patents for dental instruments and techniques, including variably tapered shaping instruments for use in endodontics. He pioneered a system-based approach to treating root canals. He is a diplomate of the American Board of Endodontics. He maintains a private practice limited to endodontics and implant surgery in Santa Barbara, Calif. Contact him at 1515 State St., Suite 16, Santa Barbara, Calif. 93101, (800) 528-1590 or (805) 899-4529, info@endobuchanan.com, www.delendo.com.
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**Fig. 1.** The Lightwalker dual wavelength, all tissue Er:YAG & Nd:YAG laser. (Photos/Provided by Technology4Medicine)

**Fig. 2.** Internal surface after conventional instrumentation, without PIPS.

**Fig. 3.** Clean dentin surface achieved with the PIPS root canal treatment.

**Fig. 4.** Higher magnification after PIPS. Collagen fibers are intact, with no thermal damage.

**Fig. 5.** Clean dentinal tubules after PIPS.

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The PHAST™ Laser Endo (PIPS™) harnesses the power of the proprietary Lightwalker Er:YAG laser, both exclusively available from Technology4Medicine (www.T4Med.com), to create photoacoustic shock waves within the cleaning and debriding solutions in the canal.

The containment of the shockwaves thoroughly streams these solutions three-dimensionally through the entire canal system, enhancing their effectiveness. The canals and subcanals are left clean and the dentinal tubules are free of smear layer. It is a well-established fact that different dental procedures require different laser wavelengths. Wavelength is important to clinical outcomes because specific body tissues interact in different ways depending on the particular laser source.

The Lightwalker is a true dual wavelength system. With the choice of two complementary wavelengths, LightWalker is the “universal” laser. Practically all laser-assisted dental treatments can be performed with either the most highly absorbed Er:YAG laser wavelength or the selectively absorbed, deeper penetrating Nd:YAG laser wavelength.

There are many advantages to using the Lightwalker and its proprietary PHAST (Photo Active Systems Technology) and PIPS for endodontic procedures:

- First is the entire root canal and subcanal system is more effectively cleaned and debrided than with traditional instrument-only techniques, reducing the risk of re-infection.
- The minimally invasive nature of PIPS preserves more tooth endoskeleton than traditional instrument techniques because filing can be limited to as small as ISO #20 or 25, maintaining more post-restoration tooth strength.
- Sub-ablative power levels eliminate the risks of thermal damage, ledging and demineralization inherent to other laser endodontic methods.
- Because the PIPS tip is inserted only into the coronal opening and not into the canal, there is no risk of tip breakage from curved canals or unwanted apical extrusion of chemical irrigants, as is possible with standard laser endodontic methods.
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Wykle Research has announced the release of two new Calasept Endo products, which it distributes for Nordiska Dental of Sweden, the manufacturer of Calasept and Calasept Plus.

Calasept Irrigation Needles are high-quality, double-side-vented, luer-lock irrigation needles that optimize the cleansing of canals, creating a “swirl effect.”

The needles are available in 27 g or 31 g, in packs of 40 needles.

Features include the following:
• Bendability
• Luer-lock hub
• Sterile and disposable
• Designed for ease in cleaning roots
• High-quality stainless steel

Calasept Irrigation Syringes are 3 ml luer-lock, single-use syringes. They are color coded to eliminate risk when using multiple irrigation liquids. They are available in packs of 20 syringes, 10 white and 10 green.

Features include the following:
• High-quality, three-part syringe
• Color coded
• Luer lock

These new products complement Wykle’s popular Calasept line, which includes Calasept and Calasept Plus calcium hydroxide paste for temporary filling of root canals, sold in packages of four syringes with 20 needles. Calasept EDTA is 17 percent EDTA solution. Calasept CHX is 2 percent chlorhexidine solution for irrigation. Both solutions are packaged with a luer adaptor for easy filling of syringes.

Wykle Research distributes Calasept Endo products by Nordiska Dental, a Swedish manufacturer of Dental supplies. Wykle Research and Nordiska Dental will continue to provide new endo products.

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Fig. 1. Seiler has a new Plasma light source.
(Photos/Provided by Seiler)

Fig. 2. A close-up view.
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