

Predictable Endo 102: Why warm and soft is go good

System 'S' for injectable or carrier-based GP

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"There's a difference between interest and commitment. When you're interested in something, you do it when it's convenient. When you're committed to something, you accept no excuses, only results."

—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.¹ The Schilder Technique involved a new and different approach for obturation of the canal system and resulted in much controversy.

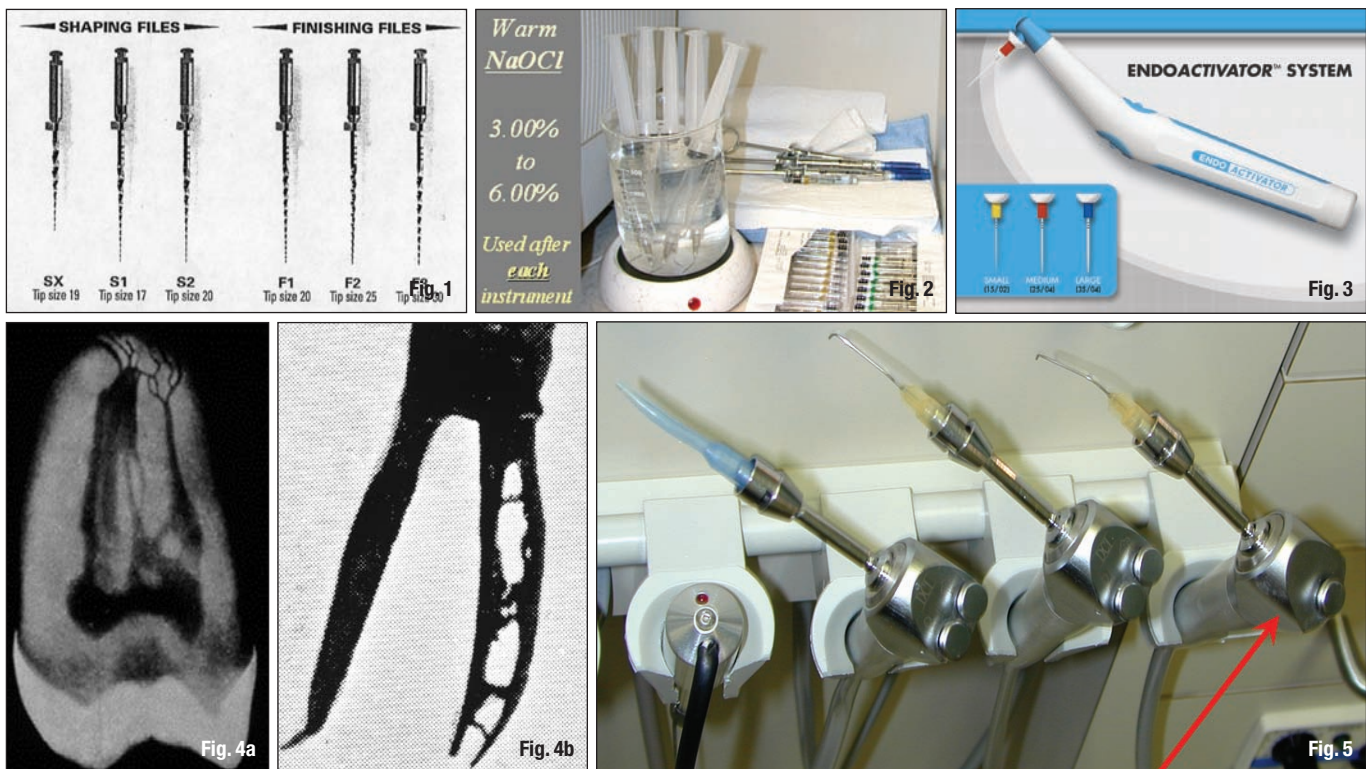
Evidently, the controversy did create interest from some doctors, because in the mid 1970s new ideas and techniques evolved that became most of what are the currently accepted concepts of modern endodontic principles and techniques. Today, the numerous clinical reports, published research and the rapid 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.² 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 ad-

equate 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 canal system, following the natural curvatures. Instrumentation beyond the apex is unnecessary and may needlessly enlarge and deform the apical foramen.³ 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 recent published research and clinical studies have confirmed the rationale for an appropriate access and correct shaping.

In the early 1990s, technology brought about the introduction of rotary instruments, relieving the op-

Fig. 1 Typical rotaries, one of several popular brands. (Photos/ Provided by John J. Stropko, DDS, unless otherwise noted)

Fig. 2 NaOCl irrigating syringes can be warmed in a beaker on a coffee warmer. Note the anesthetic syringes on a heating pad in the background.

Fig. 3 The Endo Activator is used for the 'tsunami effect' for cleaning canals.

Fig. 4a The canal system can be very complicated.

Fig. 4b The Walter Hess studies with vulcanite clearly demonstrated the complexity of canal systems.

Fig. 5 Set of three Stropko Irrigators with various 27-gauge tips bent for use. Arrow points to the dedicated 'air-only,' single-button DCI syringe.

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.)

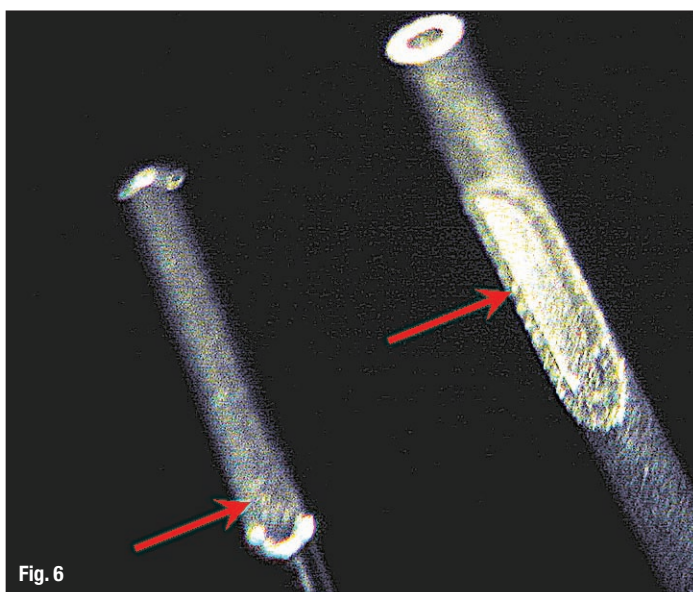


Fig. 6



Fig. 7

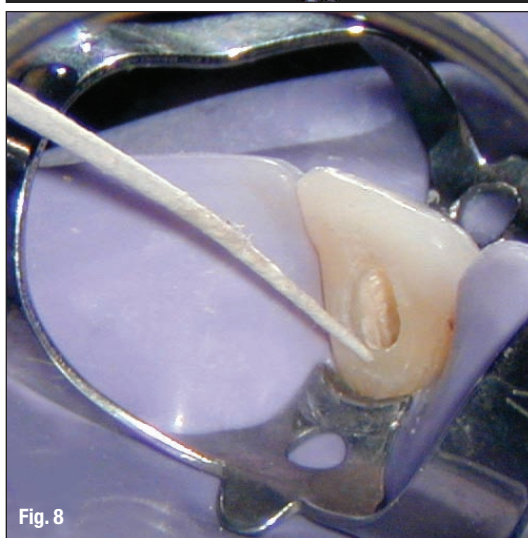


Fig. 8

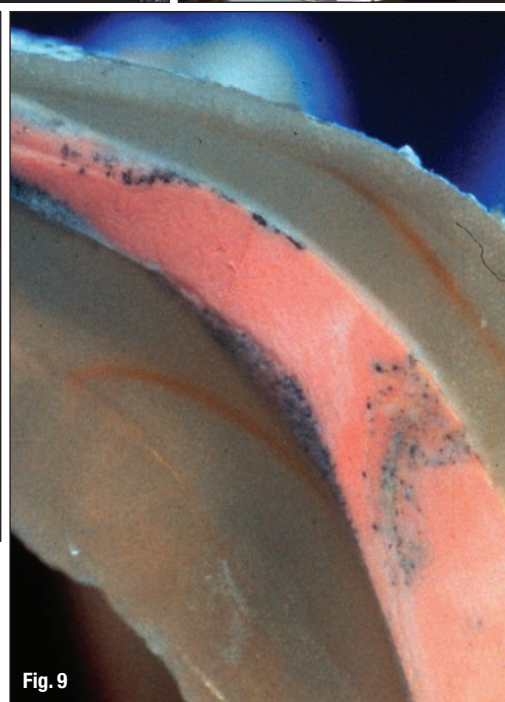


Fig. 9

erator of considerable time spent creating an acceptable shape. 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).

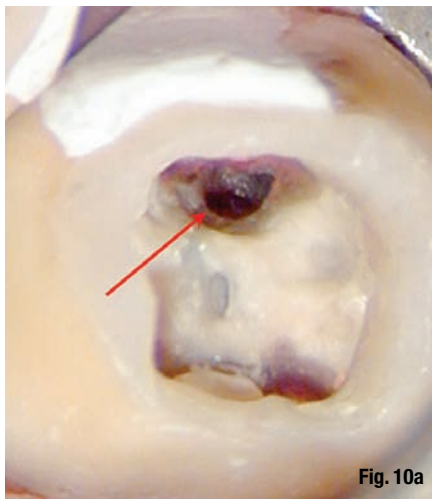


Fig. 10a

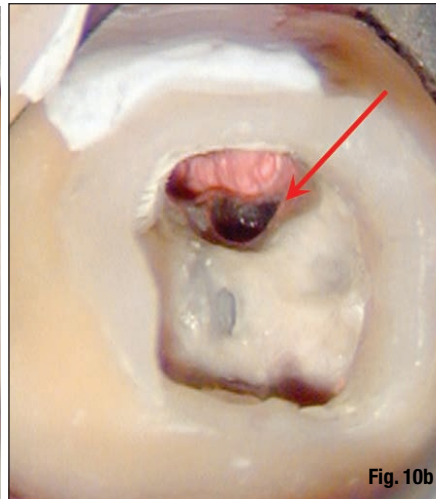


Fig. 10b

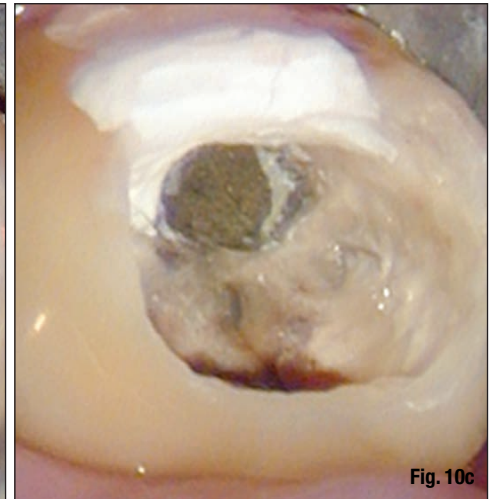


Fig. 10c



Fig. 11a



Fig. 11b

Fig. 10a_A furcal perforation in the distal root of a mandibular first molar.

Fig. 10b_Canal filled just apical to furcal perforation.

Fig. 10c_MTA placed to repair the perforation.

Fig. 11a_The Calamus Dual unit with a thermal handpiece. (Photo/ Courtesy of Dentsply Tulsa Dental Specialties)

Fig. 11b_An Obtura III Max Pack Dual also has the thermal handpiece.

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 Endo Activator (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

Fig. 12 The plugger is pre-fit, short of binding, to avoid unnecessary contact with the canal walls during deep compaction of the softened GP. (Image/Courtesy of Arnaldo Castellucci, Florence, Italy)

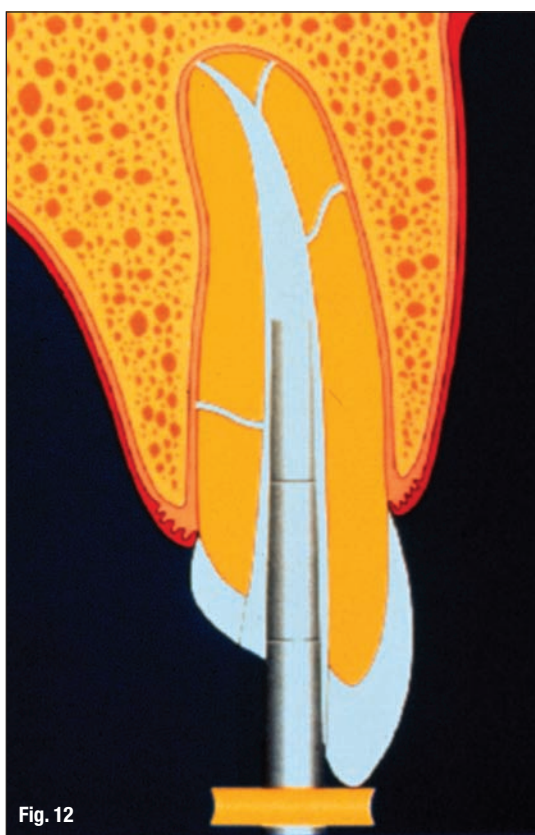


Fig. 12

Fig. 13 The GuttaCore carriers are just one of many popular products for carrier-based GP. (Photo/Courtesy of Dentsply Tulsa Dental Specialties)



Fig. 13

with an in-line regulator, the Chapman-Huffman Regulator & Gauge, Part # 17-050-00 (Fig. 7).

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.

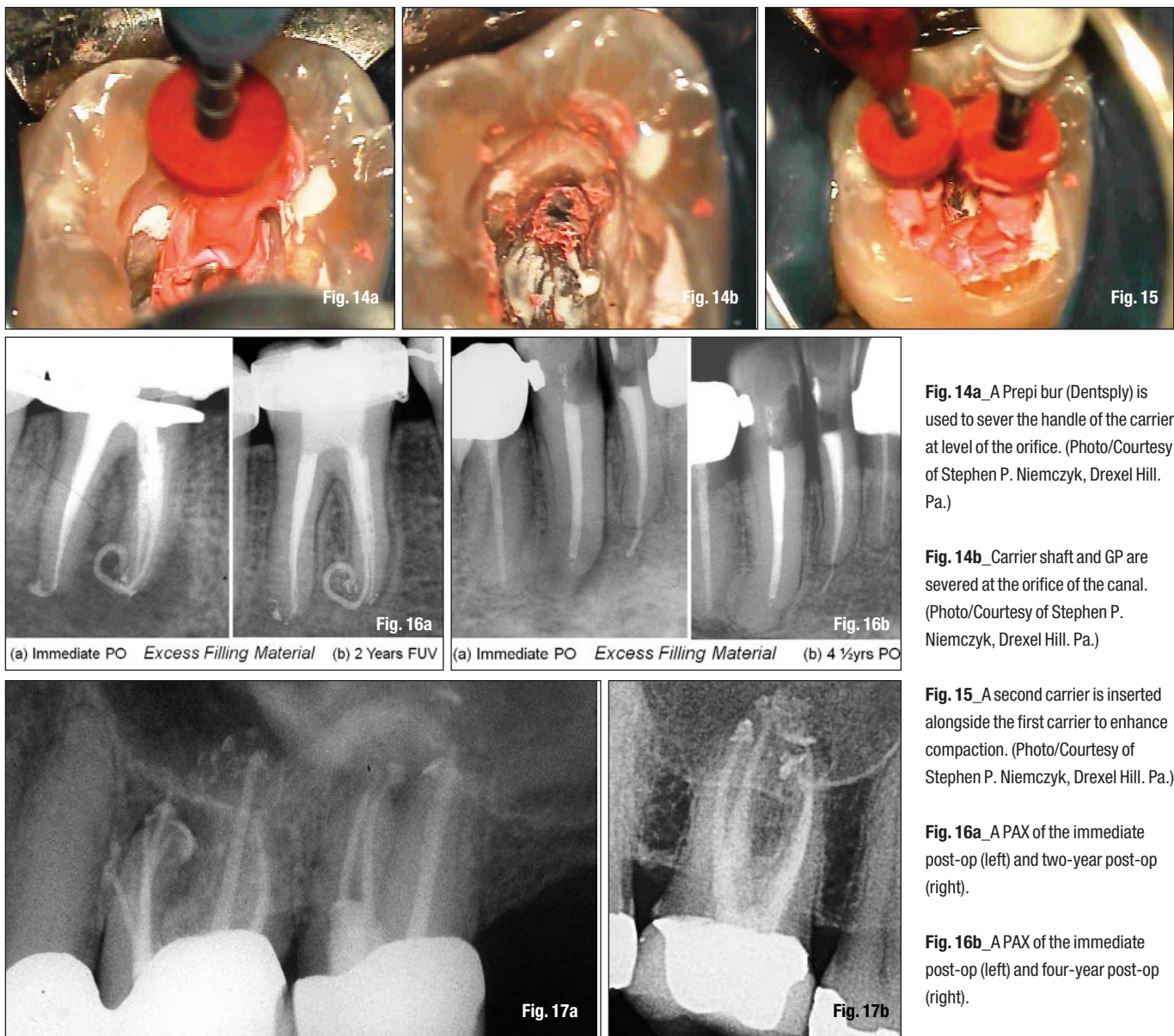


Fig. 14a_A Prepi bur (Dentsply) is used to sever the handle of the carrier at level of the orifice. (Photo/Courtesy of Stephen P. Niemczyk, Drexel Hill, Pa.)

Fig. 14b_Carrier shaft and GP are severed at the orifice of the canal. (Photo/Courtesy of Stephen P. Niemczyk, Drexel Hill, Pa.)

Fig. 15_A second carrier is inserted alongside the first carrier to enhance compaction. (Photo/Courtesy of Stephen P. Niemczyk, Drexel Hill, Pa.)

Fig. 16a_A PAX of the immediate post-op (left) and two-year post-op (right).

Fig. 16b_A PAX of the immediate post-op (left) and four-year post-op (right).

Fig. 17a_Teeth #14 & 15 obturated with Thermafil Plus. (Photo/Courtesy of Stephen P. Niemczyk, Drexel Hill, Pa.)

Fig. 17b_Tooth #3 after being obturated using the Calamus.

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 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.

Obturation by injection of thermo-plasticized GP with a Calamus or Obtura

After using the Obtura for over a decade for thermo-plasticized GP obturation, the author switched to the Calamus when it was first 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



Fig. 18 These four cases all have excellent root canal treatment, but only the third from left had the entire canal system filled at the final endodontic visit. Which one would you bet on for predictability?

smaller muscle action of using a finger to press the collar of the Calamus is significantly less, and the resulting flow of the GP can be pre-set for consistency.

The size of the needle used in the Calamus or Obtura (20 vs. 23 gauge) is generally a matter of preference and can also depend on what the canal wants. It does not make any difference, in the scheme of things, how far apically into the canal the needle is placed, as long as it is non-binding.⁴ For example, straighter and larger canal will take a larger needle.

On some occasions, the 20-gauge needle will not be far enough apical to the orifice of the canal before binding. If the canal preparation is narrower, this is an indication to use the smaller, 23-gauge needle. As long as it is not binding and the canal has the correct shape, the GP will flow to the apex. Note: If the canal is parallel in shape, the canal then becomes an extension of the needle and apical control is severely handicapped. Shape is of the utmost importance, especially in these techniques.

The settings on the Calamus are checked to assure the desired set temperature has been achieved (the author uses 160 C), and the flow rate is set correctly (the author prefers 100 percent). When the unit reaches the set temperature, it will stop blinking. Note: As a safety feature, until the unit has achieved the pre-set parameters, the motorized plunger will not initiate and GP is not ejected. When all is ready,

the collar is pressed until the initial GP is extruded and then the collar is released. The slight amount of GP at the tip is removed.

The needle is then placed into the canal apically, just short of binding, and the collar is pressed to re-activate the plunger and initiate the flow of GP. It is good practice to barely move the tip, in a very slight apical-coronal direction as the GP is flowing. The moment there is a sensation of pushback, a momentary, very slight apical resistance can be exerted, then begin to slowly withdraw the needle until the GP fills the canal to the orifice. Using an SOM, this is easily observed and gives the operator confidence.

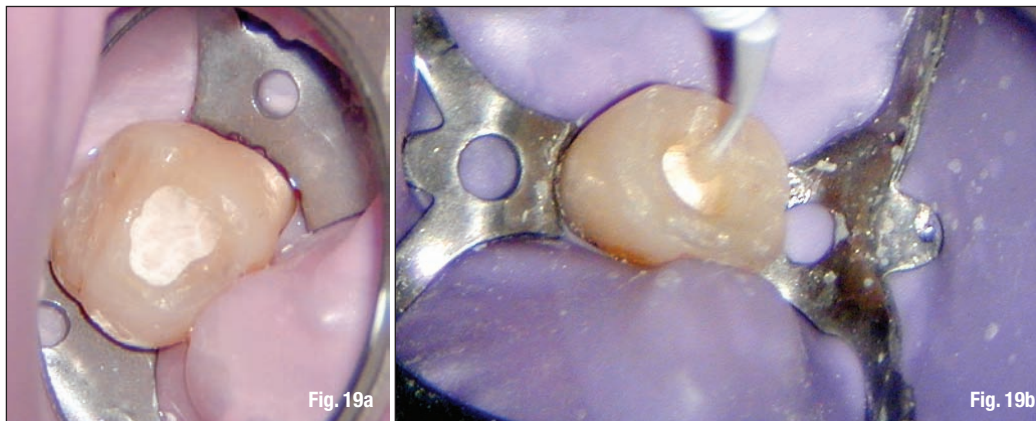
If there are two or more canals in the same root, they must be injected in a special manner, especially if they join or are connected by any variation in the canal system (an isthmus, for example). Obturation is accomplished by filling both of the canals in rapid succession to the desired level in the orifice. Then immediately proceed to the first canal with a pre-measured plugger to create more hydraulics (deep pack) and start the compaction process. The GP will remain soft for enough time so the operator can accomplish the shepherding process in two or more canals if done in a timely manner.

To insure complete adaptation to the walls of the canal, the warm GP needs to be compacted as it cools to overcome any shrinkage that will normally occur. Since the softness of the GP is mass-dependent, the GP at the orifice level has the greatest mass and will stay softest for the longest time in the canal, regardless of which technique is utilized. Using the Calamus, a pre-fitted Schilder #9 plugger, well short of binding, is then used to compact the GP to the pre-measured depth (Fig. 12).

The plugger is firmly pushed into the soft GP and held at the measured depth for just a few seconds to achieve compaction of the GP in the apical third. The plugger is now used to "shepherd" the GP from the walls of the canal into a "wad" and further compact the GP. The operator works toward the orifice in approximately 2-mm steps as the plugger creates "new wads" in the process. The shepherding of the GP is continued until the desired depth in the orifice is reached. The mistake often made when working with warm GP is the tendency to "bounce" off the GP

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
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Table 1



Figs. 19a,b A bonded temporary that has been in place for three months without leakage.

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).⁵ 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 sufficiently sharp 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.

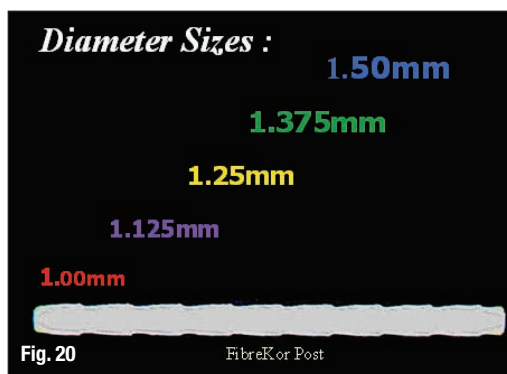
The resistance it encounters is a function of the file/carrier being distorted by the curvature of the canal space; the greater the curvature, the greater the distortion and resistance (and the greater the chance of contacting the carrier on two opposing sides during insertion, possibly stripping the 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

Fig. 20 The FibreKor posts have a wide selection of posts with good retention and are easy to use.



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.

Excess filling material

Historically, any time a case was obturated, there was much concern when anything was extruded

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/obturated 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.

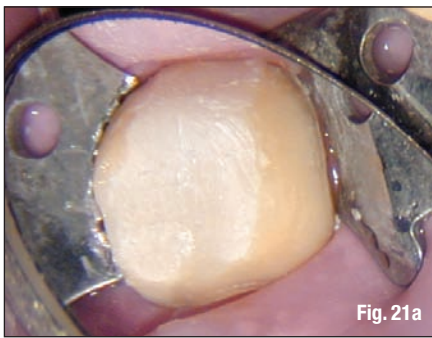
A good way to imagine what is happening, while using thermo-plasticized GP in a properly shaped and patent canal, is to envision everyone in a theater rushing to get out the same door in a big hurry. The GP molecules are relatively large and warm, so the continually tapering shape is, in itself, a limiting 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.

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.

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."⁶ 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 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.⁷ 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 the sterility of the system. 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 (Dentmat). CaOH (Ultracal by Ultradent) is injected into the canal system and covered with a sterile cotton pellet. Then Tenure Uni-Bond is used to condition the access opening, lightly air dried and Core Paste is injected to fill the opening. 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.

On occasion, a patient is unable to keep the appointed return visit and may have to delay his or her return visit for weeks or months (Fig. 19). 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.⁶

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

Figs. 21a–c. The canal systems have been filled 100 percent and are ready for restorations without any concern for micro-leakage until they are more permanently restored.

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 air 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 (Den Mat) for conditioning of the dentin, air drying between each and inject Core Paste (Den Mat) 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. Weine has stated that more endodontically treated teeth are lost due to improper restoration than to endodontic failure.⁸ 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.⁹ It is necessary to appreciate some basic restorative/prosthetic 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.¹⁰

It is critical that a minimal circumferential ferule 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.¹¹ 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.¹² 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.¹³ 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 endodontic and restorative to be a team, working together for predictability, in the interest of the patient.

Our job as "endo-doers" is to learn, become teachers and educate 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?_

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about the author

roots

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.

