The System 'S' technique: to seal the entire canal system for 'success'

Author_ John J. Stropko, U.S.A.

A "system" is defined in Webster's Dictionary as a series of events or processes that together accomplish a result. A few examples: the digestive system, the solar system, a system of government, System "B," etc. In the same way, System "S" does not just refer to the injection of thermo plasticized gutta-percha (GP), but rather to a specific protocol to maximize the three-dimensional sealing of the entire canal system to increase the predictability of success. The System "S" technique, when used in its entirety, will prevent most of the unfavorable post-op events that can, over a period of time, lead to a lack of predictability of endodontic treatment.

There are six important components to the System "S" technique:

1. Proper shaping with patency.
2. Adequate cleaning and drying.
3. Delivery of pre-warmed GP to apex (Calamus, BeeFill).
4. Coronal seal for the rest of the system.
5. Respect for the endo-pros relationship.
6. Use of the Operating Microscope (OM) for the entire endodontic treatment.

There are currently seven generally used methods utilizing GP as the obturation material of choice:

Fig. 1a_The Calamus unit with single-use cartridges, available in North America from Dentsply.

Fig. 1b_The BeeFill Flow Unit, available in Europe from VDW.

1. Single cone.
2. Lateral condensation.
3. Chlorapercha technique.
4. Vertical compaction of warm GP (Schilder, continuous wave, McSpadden, System "A").
5. Carrier-based (Thermafil).
6. Injection of thermo-plasticized GP (often referred to as "squirting") by use of a Calamus, BeeFill or Obtura unit.
7. Mechanically assisted compaction (Pac Mac).

No matter the GP technique used, shape is of importance. However, when using any warm GP obturation technique (Nos. 4, 5 and 6 in the list immediately above), the proper shape is essential for success. Fortunately, since the availability of rotary instrumentation, the correct shape has become easier to achieve.

It has been shown that the introduction of pre-warmed, pre-softened GP into the canal system, with an injection technique, demonstrated the best adaptation to the prepared root canal.[1] The author believes that as long as the GP is introduced pre-warmed and pre-softened to the apical third, the deformation and adaptation to the canal walls is more predictable for a better seal. The injection of warm GP (Calamus, BeeFill or Obtura), or the use of carrier-based obturators (Thermafil) are the most popular methods used to achieve this goal.

After using the Obtura for over a decade to inject thermo-plasticized GP for obturation, the author switched to the Calamus (Figs. 1a, 1b) when it was introduced several years ago. Since the author changed to the Calamus unit and numerous canals were obturated with it, several advantages were noted when compared to the Obtura:

CALAMUS	OBTURA
1) Flow is consistent and can be pre-set.	1) Flow is dependent on operator's "squeeze."
2) GP and needles in sterile cartridges.	2) Pellets delivered in an unsterile box.
3) Single needle use the norm.	3) Multiple needle use the norm.
4) Barrier protection easy to place.	4) No barrier protection between patients.
5) Less patient discomfort upon injection.	5) Patient often felt a "flash of warmth."
6) Easier to relate/teach proper use.	6) Proper "squeeze" a longer learning curve.
7) Can easily be rotated ergonomically.	7) Unit difficult to turn to some angles.
8) No hand fatigue during use.	8) Hand fatigue can occur.
9) No patient response during obturation.	9) Patients often felt apical pressure.

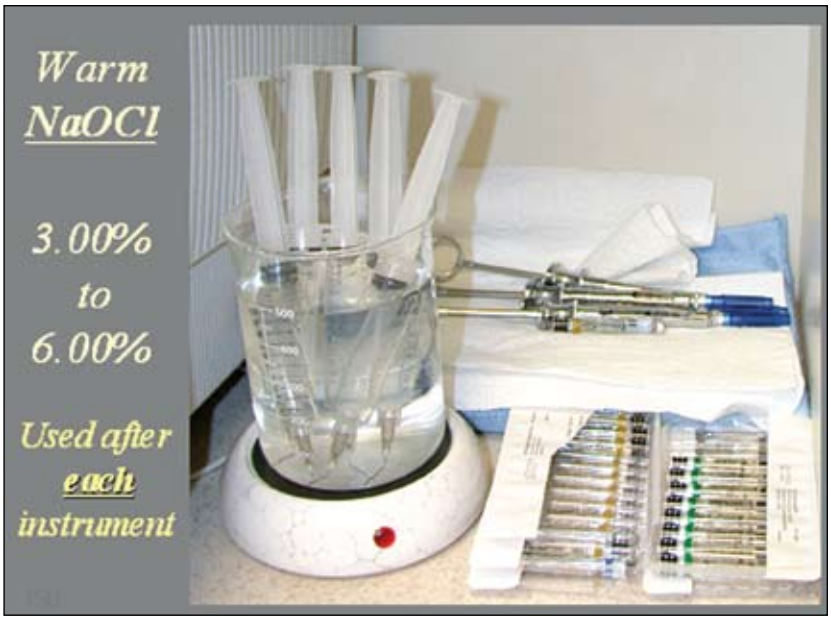


Fig. 2_NaOCl irrigating syringes can be warmed in a beaker on a coffee warmer. Note the anesthetic syringes on a heating pad in the background.

Shaping the canal

After placement of the rubber dam, an appropriate access is made. A proper access will facilitate the creation of the continuously tapering shape of the canal, necessary for any warm GP technique. Shaping should be confined to the canal. Instrumentation beyond the apex is unnecessary and may needlessly enlarge and deform the apical foramen. The apical terminus of the canal(s) should be kept as small as practical, and patency must be maintained.[2] Disinfecting irrigation (3-6 percent warm NaOCl) is used between each instrument during the entire shaping process, and patency is continually checked with a #10 file. *(Note: The quantity of irritants used is not as important as the frequency of use.)*

Irrigation for cleaning the canal

During the shaping process, 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 (disinfect and stop action of the EDTA).

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 (H_2O_2, Chlorhexidine, 17 percent aqueous EDTA, MTAD, etc.) can also be used alternately, depending on operator preference. Close observation

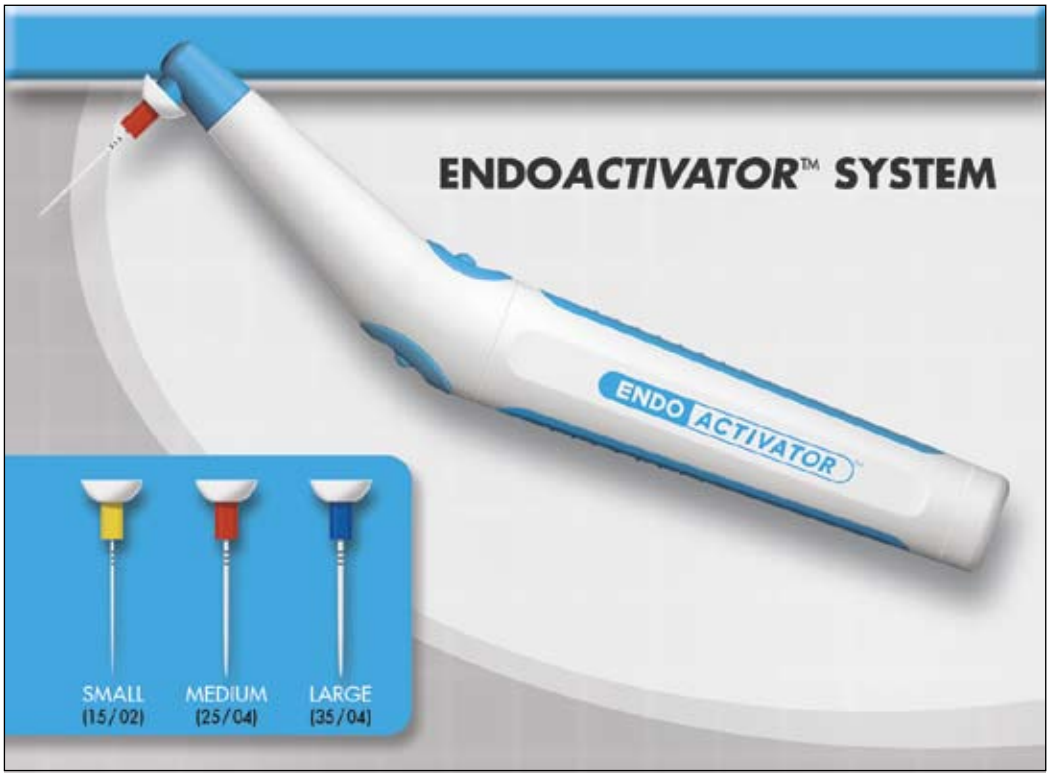


Fig. 3_The EndoActivator is used for the tsunami effect for cleaning canals.

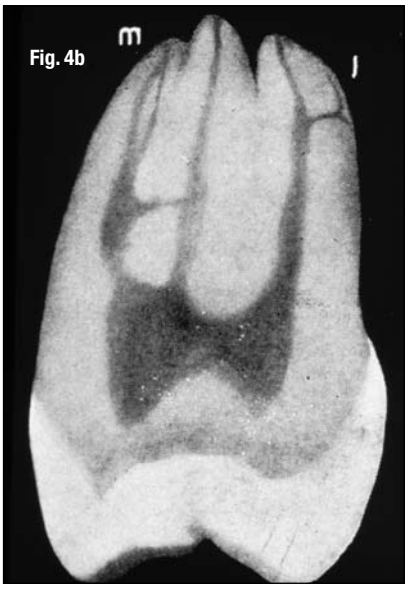
with an OM will clearly indicate complete cleaning of the canal system when no debris is flushed out during the irrigation process. During the evacuation with the capillary tip, it becomes apparent if there is a joining of the canal systems within the root. For example, if using the OM, as the MB1 canal 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 does join at some point (Figs. 4a–4c). There are occasions, especially in lower molars, where the mesial root canal system unexpectedly joins with the distal root canal system. Sometimes, 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 injecting thermoplasticized GP.

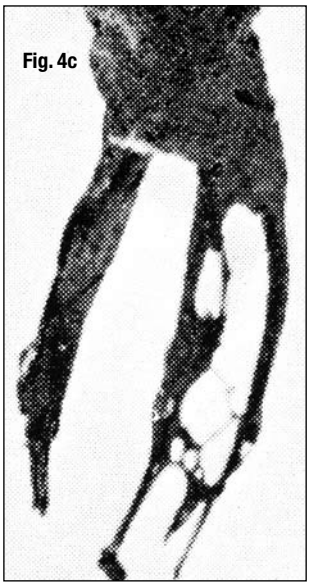
Drying canals with F·I·R·E

The canal(s) are **F**looded with 95 percent ethanol (Everclear, at local liquor store), agitation of the fluids are **I**nitiated with the EndoActivator for the "tsunami effect," **R**e-irrigated with the 95 percent ethanol, and **E**vacuated with the capillary tip. The canal(s) are then dried best by using a Stropko Irrigator on a dedicated, air-only syringe (*www.stropkoirrigator.com*), but if a three-way syringe is used, be sure to express all water from the line first (Figs. 5a, 5b). Next, with a 27-gauge or 30-gauge notched or side-vented needle (Monoject), fitted to the tip of the Stropko Irrigator and bent to the appropriate length, the canals are easily and quickly dried (Fig. 6). ***Important note:*** *It is essential to regulate the air pressure to the syringe at 1–3 lbs/in² and use a side-vented or notched needle, to prevent any possibility of inadvertantly forcing air through the apical foramen.* This is easily achieved 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. 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 (the eye or ear) to be sure the air is even flowing. But, just watching the evaporation with the OM is enough to convince the operator that there is indeed a flow of air. In over 15 years with many different dentists using the Stropko Irrigator to "air dry" canals, the author has only heard of one unfavorable incident! In that one case, the dentists 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 (1–3 lbs/in²) and the appropriate gauge (27-gauge or 30-gauge), side-vented needle is used, there is enough physiologic back pressure at the apex to prevent movement of the air past the apex.

Sealer application

To the OM 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





Figs. 4a–4c_When there are two canals in the same root, it is good to know whether they are connected somewhere in the system before obturation is done. (Fig. 4a courtesy of Gary Carr, PERF, San Diego, Calif. Fig. 4c is from the classical "Root Canal Morphology Study" done by Hess & Zucker in 1925.)

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. The Kerr Pulp Canal Sealer EWT is mixed per usual directions and can be a little "on the thin side." The paper point is coated with the Kerr Pulp Canal Sealer and placed into the canal to the working length (Fig. 8). Using short, rapid movements, the walls of the canal are completely coated with the sealer (Fig. 9). The use of the OM is a great aid to observe when the coating of the canal wall by the sealer is complete. Then, a clean absorbent point is used, in the same manner, to remove any excess sealer. Depending on the amount of sealer placed at the beginning, more than one clean absorbent point may be necessary to get the "blotched appearance" desired on the final point. Only a thin coat of sealer is necessary for lubrication (Figs. 10a, 10b). One of the most common mistakes, made at first, is using too much sealer. When this happens, many additional paper points, and time, are required to achieve the "blotched" effect desired. Typically, only one or two points are normally needed once the operator achieves proficiency at applying the correct amount of sealer in the first application. This technique is not sealer dependent and uses the sealer as a lubricant to facilitate the flow of the GP while injecting the warm GP with the Calamus.

Fig. 5a_Set of three Stropko Irrigators.

Fig. 5b_Dedicated, air-only, single-button DCI syringe with 27-gauge "notched" needle bent for use.

Injection of the thermo-plasticized GP

The size of the needle used in the Calamus (20-gauge vs. 23-gauge) is generally a matter of preference and depends 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.[3] The straighter and larger canal can take a larger needle. If the canal preparation is narrower, the narrower needle should be used. On some occasions, the 20-gauge needle will not be very far into the orifice of the canal before binding. This may be an indication to use a 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*

Fig. 6_When drying canals with air, needles must be notched or side-vented.

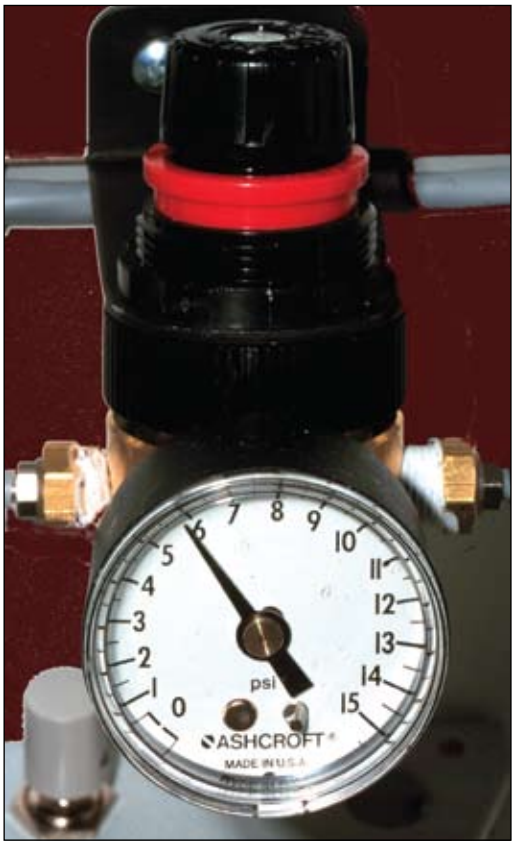


Fig. 7_The Chapman Huffman in-line air regulator and gauge (Part No. 17-050-00) is very easy to use.

Fig. 8_Coating Kerr Pulp Canal Sealer EWT onto a sterile absorbent point.

needle and apical control is severely handicapped. Shape is of the utmost importance, especially in this technique!)

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 as far as it will go apically into the canal, just short of binding, and the collar is pressed to reactivate the plunger and initiate the flow of GP. It is good practice to barely move the tip in a slight apical-coronal direction as the GP is flowing. The moment there is a sensation of "push-back," a momentary, very slight apical resistance can be exerted, and then begin to slowly withdraw the needle as the GP fills the canal to the orifice. The needle is slowly backed out as the canal fills. In the microscope, this is easily observed.

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.

Compaction of the warm GP

Since the softness of the GP is mass-dependent, the GP at the orifice has the greatest mass and will stay softest for the longest time in the canal. A pre-fitted plugger (well short of binding), usually a Schilder #9 (Caulk) or a Dovgan #60 (Miltex) is then used to compact the GP to the pre-measured depth on the plugger (Fig. 11). 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 while compacting, instead of giving the GP time to compact. Just a few seconds are needed for the newly compacted "wad" to cool.

Excess filling material

The biggest fear of the new user of System "S" is "there will be a great amount of excess filling mate-

rial at the terminus." The opposite is generally true. The most common problem is the inability to get to the terminus and completely fill/obturate the canal system. The usual reason for this is the absence of patency, an improper shape, or fear of the operator to use enough pressure during the injection or compaction process. A good way to imagine what is happening while injecting the GP in a well-shaped, patent canal is to envision everyone in a theatre 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. 12a–12j). However, it makes sense that the larger the apical opening, the greater the amount of excess material might be extruded. This is the essence of the learning curve when beginning to use the injection of thermo-plasticized technique. The consistent flow of the Calamus unit does make the learning curve quicker and easier to master. 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. The technique is easy, fast and predictable for obturation if all is done as described.

Now for the rest of the seal

The final step of the System "S" technique 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."[4] To illustrate this concept, look at the four cases shown (Fig. 13), 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 (Fig. 13c).

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:

- Patient is "in-the-chair."
- Patient is anesthetized.
- Rubber dam is in place.
- Access is sterile for placement of the foundation restoration.
- All previous restorative materials are easily removed.
- The "endo-doer" has microscopically enhanced vision.
- No one knows the canal system as well as the "endo-doer."
- No chance of contamination of the canal system.
- Inadvertent perforations are eliminated.
- Tooth can be "roughed prepped" with dam in place.
- Patient has more time to plan final restoration.
- After RCT, the dentist knows, within two minutes, the time to schedule for crown prep.
- 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.[5] Therefore, it behooves us to do all that is possible to prevent it. If multiple visits are required, the dentist 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 (Denmat). The Tenure Uni-Bond is used to condition the access opening, lightly air dried and then Core Paste is injected to fill the opening (Figs. 14a–14c). After just a few minutes, the auto-cure Core Paste is set completely and the occlusion is ready to check, to make sure there are

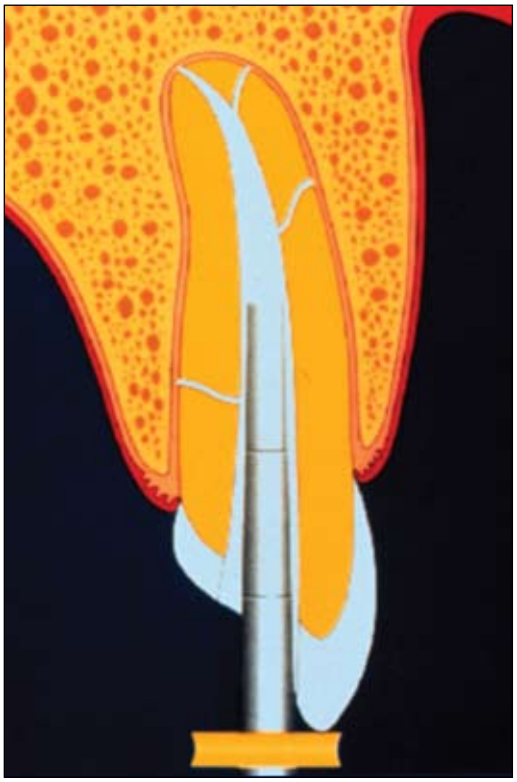


Fig. 9_Coated absorbent point inserted to working length into the canal.

Fig. 10a_Fresh absorbent points are used to remove excess sealer until "blotchy."

Fig. 10b_ Only a very thin layer of sealer needs to coat the walls for lubrication. (Photo courtesy of Dr. Bob Sharp)

Fig. 11_ Plugger is pre-fit, short of binding, to avoid unnecessary contact with the canal walls during deep compaction of the softened GP. (Illustration courtesy of Dr. Arnaldo Castellucci)

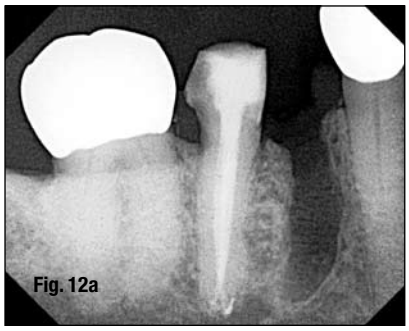


Fig. 12a

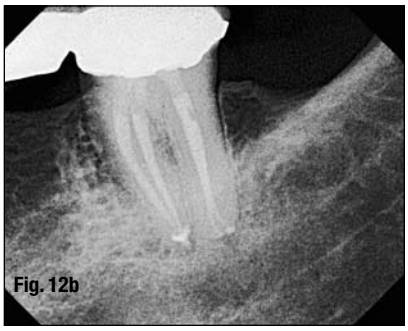


Fig. 12b

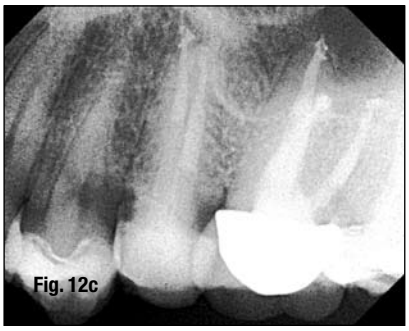


Fig. 12c

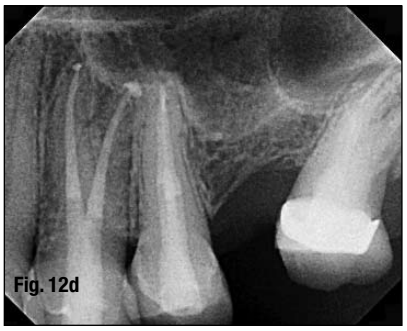


Fig. 12d


Fig. 12e


Fig. 12f


Fig. 12g

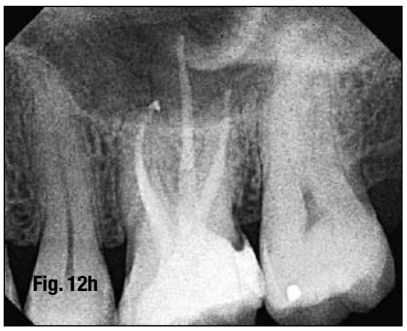


Fig. 12h

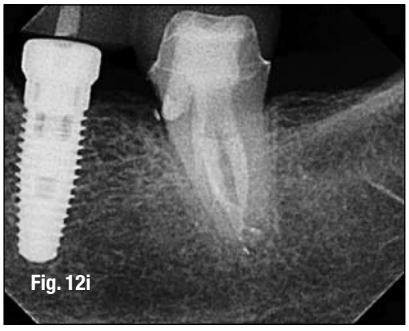


Fig. 12i


Fig. 12j

Figs. 12a–12j_When the shape is correct and the apical opening kept as small as practical, a small "puff" of excess material is predictable.

no interferences. On occasion, a patient is unable to keep the appointed return visit. There may be an important change of events in his or her life, or the dentist 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 (Figs. 15a, 15b). Who would be better to control the coronal aspect of the tooth following endodontic obturation than the "endo-doer" while the case is isolated with a rubber dam in place? As Dr. Denny Southard of Tulsa, Okla., commented almost 10 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.[4]

An easy foundation restoration technique

After the obturation of all canals, the GP is removed to the proper depth in the orifice as required for retention. This is quickly and easily done using a Mueller Bur at approximately 20,000 rpm. If a post space is required, the same bur can be used to remove a little GP at a time until the desired depth is reached. Using the OM and the Mueller Bur while the assistant uses an appropriate tip (Vista/Ultradent) on the Stropko Irrigator, all remaining bits of sealer and GP are gently removed from the access.

Then the access is flooded with 95 percent ethanol to remove any remaining sealer and scrubbed with a micro-applicator (Vista, 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 350 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.

Rinse and air dry the access, and then flood it with 37 percent phosphoric acid gel (UltraEtch, 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, a FibreKor post (Pentron) can be cemented with the initial application of Core Paste. The FibreKor post kit has a very good selection of sizes. The 1.125 mm (lavender lid on tube) fits most of the post spaces passively (Fig. 16). 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. 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. 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, can be "stacked" or added onto so enough bulk is easy to achieve the desired buildup, and it always sets up in about three minutes. The tooth can then be rough prepped and returned to the referring dentist (Figs. 17a–17c). At any rate, the endodontically treated tooth is ready for the final crown prep and impression if the dentist wishes to do that 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.[6] 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.[7] It is necessary to appreciate some basic restorative/prosthodontic principles to establish the 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.[8] It is critical that a minimal circumferential ferrule of 1–2 mm be established for retention of the restoration. A biological width of approximately 2–3 mm is required between the osseous crest and the cervical margin of the restoration.[9] 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. 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 shap-

Fig. 13_Four cases of well-sealed apical halves of canals but No. 3 is most predictable because the entire system was sealed at the same time as the fill.

Fig. 14a_Access with sterile cotton pellet over CaOH-ready temporary restoration.

Fig. 14b_With a small brush or micro-applicator, the Tenure Uni-Bond is applied.

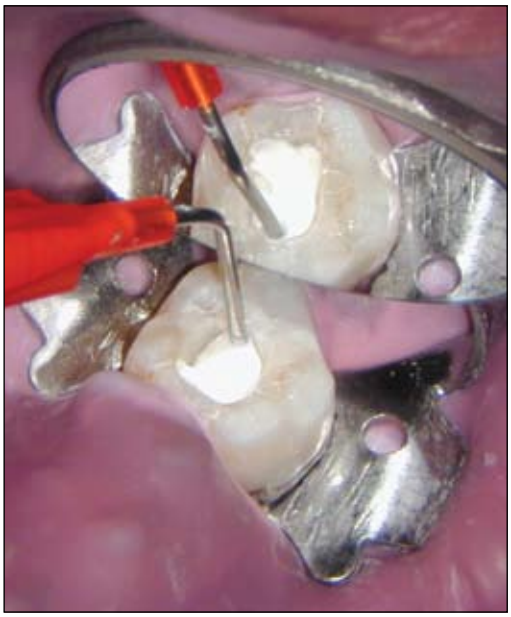


Fig. 14c_Core Paste is injected for a dependable intra-appointment seal.


Fig. 15a


Fig. 15b

Figs. 15a, 15b_Core Paste temporaries that have been in place for more than two months.

Fig. 16_FibreKor Post comes in a variety of sizes. The 1.125 size pictured fits most post spaces passively with little or no reshaping of the post.

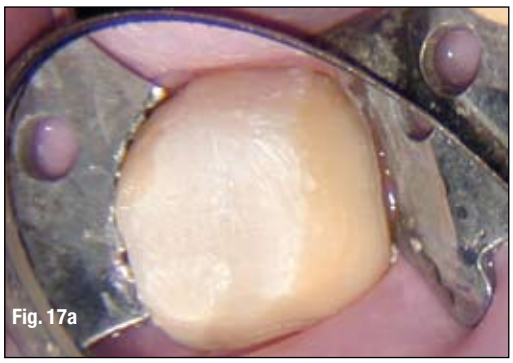


Fig. 17a


Fig. 17b

Figs. 17a, 17b_These "rough prepped" foundation restorations are ready for provisionals, or final preparations and impressions.

Fig. 17c_Foundation restoration ready for crown preparation when endodontist is ready.

ing the canal system. Only enough tooth substance should be removed to achieve the desired shape needed to completely 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.

Once the referring dentists 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, exclusively, for obturation, but other 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.


Fig. 17c

A survey of endodontists taken about three years ago stated that 38 percent always used an OM, 30 percent sometimes used it, and 32 percent never used it.[10] The use of an OM 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. If we don't see it, we don't know it! A good example is the high percentage of fourth canals that can be found in the maxillary molar segment. The clinical use of the OM significantly increased the number of canals that were discovered.[11] 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.

Our job as "endo-doers" is to learn, become teachers, and educate the patients, staff and dentists we work with so we can achieve dental health as a team. Let us not "cave in" to 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

1. Weller RN, Kimbrough WF, Anderson RW. A comparison of thermoplastic obturation techniques: adaptation to the canal walls. J Endod. 1997;23(11): 703-6.
2. Schilder H. Cleaning and Shaping the Root Canal. Dent Clin North Am. 1974;18 (2):269–96.
3. Veis A, Lamianidis T, Molyvdas I, Zervas P. Sealing ability of sectional injection thermoplasticized gutta-percha technique with varying distance between needle tip and apical foramen. Endod Dent Traumatol. 1992;8 (2):63–6.
4. Southard DW. Immediate Core Buildup of Endodontically Treated Teeth: The Rest of the Seal. Pract Periodontics & Aesthet Dent. 1999;11 (4):519–26.
5. Heling I, Gorfil C, Slutzky H, Kopolovic K, Zalkind M, Slutzky-Goldberg I. Endodontic failure caused by inadequate restorative procedures: review and treatment recommendations. J Prosthet Dent. 2002;87(6):674–78.
6. Weine FS. In: Endodontic Therapy. 5th Ed. St. Louis, MO:Mosby, 1996:4.
7. Salehrabi R, Rotstein I. Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study. J Endod. 2004;30 (12):846–50.
8. Kois J. Implants – Restorative Heroics vs. Replacement Antics, 47th Annual Meeting American Equilibration Society, Feb. 21st, 2002, Chicago, IL.
9. Goldberg PV, Higginbottom FL, Wilson TG. Periodontal considerations in restorative and implant therapy. Periodontol 2000. 2001;25:100–9.
10. Dental Products Report Survey: Endo Survey to Dentists. Dental Products Report. July 2004, p.20.
11. Stropko J. Canal Morphology of Maxillary Molars: Clinical Observation of Canal J of Endo, 1999;25 (6):446–50.

_About the author

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John J. Stropko, DDS

Dr. John J. Stropko received his DDS from Indiana University in 1964, and for 24 years he practiced restorative dentistry. In 1989, he received a Certificate for Endodontics from Boston University and recently retired from the private practice of endodontics in Scottsdale, Ariz. Dr. Stropko is an internationally recognized authority on micro-endodontics. He has been a visiting clinical instructor at the Pacific Endodontic Research Foundation (PERF), an adjunct assistant professor at Boston University and an assistant professor of graduate clinical endodontics at Loma Linda University. 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 textbooks, and is an internationally known speaker. Dr. Stropko has performed numerous live micro-endodontic and micro-surgical demonstrations and, along with Dr. Joseph Dovgan, is a co-founder of Clinical Endodontic Seminars. He is currently on the endodontic faculty at the Scottsdale Center for Dentistry in Scottsdale, Ariz., as an instructor of micro-surgery. Dr. Stropko and his wife, Barbara, currently reside in Carefree, Ariz. You may contact Dr. Stropko at topendo@aol.com.