Predictable Endodontic Success: Part II — Microstructural Replication

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The seminal article on warm vertical condensation of gutta-percha by Dr. Schilder[1] demonstrated that hydraulic forces applied to thermo-softened gutta-percha would fill the anatomical irregularities of the root canal space in an unprecedented manner. Obturation of the prepared root canal space was changed forever by this milestone in the history of dentistry. While Dr. Schilder's technique radically improved the gravitometrics of obturation, it nonetheless relied on gutta-percha, first introduced to dentistry in the 1850s. Gutta-percha is not however, the ideal "alloplastic implant" material to position against the wound area of the prepared apical connective tissue.

Gutta-percha, the milky juice of *Palaquium gutta* and other evergreen trees in the Malayan Archipelago is collected by felling the tree and allowing the sap to coagulate; it is then washed, purified, and molded into bricks for processing. It is a polyterpene, a polymer of isoprene, an inelastic polymer as it has a trans molecular structure. It has been coated on gold wires,[3] rolled into points, infused with chemicals such as vermilion[4] and antiseptics, softened with rosins[5] and manipulated in a variety of protocols to enhance it's sealing ability and obviate the concept that the primary failure of root canal therapy results from apical percolation of fluids and microorganisms into a poorly obturated root canal system.

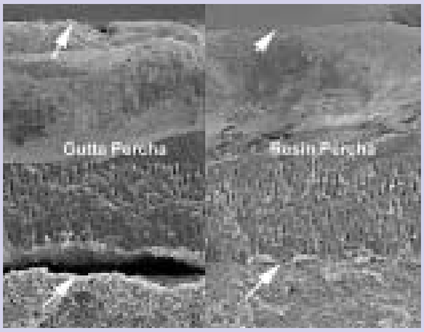


FIGURE 1A—The image shows SEM's that are stacked vertically and horizontally. Vertically—low resolution 15X power on top and high resolution 40X power on the bottom. Horizontally—Gutta-percha on the left, resin-percha on the right. It should be evident that the ability to microstructurally replicate the root canal system is dramatically more apparent with the Epiphany Obturating System.

FIGURE 1B—Radiographically, the traditional warm vertical gutta-percha technique appears to achieve the biologic imperative of total filling of the root canal space.

FIGURE 2—The Obtura II system includes applicator tips in 20, 23 and 25 gauge sizing which enables delivery of thermo-softened gutta-percha or resin-percha into a myriad of complex canals of varying length.

The definition of obturation according to the Merriam-Webster dictionary means to close or obstruct which is inconsistent with the biologic imperative that mandates endodontic success. To quote Dr. Gunnar Hasselgren;[2] "endodontics continues to constantly and incorrectly use the term obturate to denote filling in three dimensions." It is technically impossible to make a two-dimensional filling in a three-dimensional world and the root canal filling must fill, not obturate the root canal space. Furthermore, if obturation is the condensation of a thermoplastic material, it is analogous to the technique of injection molding used in polymers, not to putting a cork in the end of a bottle.

The evaluation of molecular, oligomeric and polymeric material usage at high temperature and stress which

Table 1
Force measured in Newtons required to cause vertical root fracture (n=16)

Groups	Mean	Standard Deviation
1 — Control-no obturation	465.39^{ab}	76.85
2 — Lateral Gutta-percha	391.51^{a}	146.79
3 — Vertical Gutta-percha	392.37^{a}	77.03
4 — Lateral Resylon™	504.22^{b}	195.94
5 — Vertical Resylon™	498.23^{b}	135.32

FIGURE 3—Epiphany primer will enable bonding of the Epiphany sealer to the walls of the canal space. The catalyst contained in the sealer will polymerize the primer and bond the sealer to the walls. The sealer will in turn bond to the resin in the Epiphany cones creating a monobloc that is designed to strengthen the root, resist leakage and entomb bacteria.

FIGURE 4—The System B Heat Source enables an exact temperature setting to be maintained throughout the procedure. This is of particular importance with the lower temperature settings necessitated by resin-percha material.

then undergoes material degradation due to intrinsic damage caused by microstructural deterioration is measured by the standard of "microstructural replication". It is the opinion of the authors, that the term obturation be replaced by microstructural replication as being more exacting by definition of the desired end result of sealing the root canal system.

Recently, a new product has been introduced to the endodontic marketplace. Resylon (Pentron Corp., Wallingford, CT) is a thermoplastic, synthetic polymer substitute shown to seal significantly better than gutta-percha[6,7] (Figs. 1A & B). According to preliminary data from a study conducted at the University of North Carolina,[8] Resylon demonstrated the capacity to strengthen an endodontically treated tooth by 30% over a gutta-percha control (Table 1).

Different superscript letters represent statically significant differences ($p<0.05$).

The material is radiopaque and can be retrieved if necessary using conventional gutta-percha solvents. Marketed as the Epiphany Obturating System, the material will be available in .02, .04 and .06 cone sizes, conventional sizes and plugs for the Obtura II™ Gutta-Percha System (Obtura/Spartan, Fenton MO) (Fig 2).

The packaging will include Epiphany (Resylon) points and Epiphany sealer, a dual cure resin sealer containing calcium hydroxide. The sealer is dispensed from an automix double barrel syringe and is highly radiopaque. The sealer can be light cured for immediate coronal seal, or will self cure in 25 minutes. With a pH of >11.5, it is bacteriostatic. Once set, the pH is rendered neutral; however, if fluids penetrate the canal space, the pH will rise again to >11 re-establishing a bacteriostatic environment. It will leach out calcium and hydroxyl ions while taking in phosphate ions from the fluid. Non-toxic, non-mutagenic and non-irritating, the sealer is resorbed by phagocytosis if expressed beyond the canal confines. Epiphany primer will enable bonding of the Epiphany Sealer to the walls of the canal space. The catalyst contained in the sealer will polymerize the primer and bond the sealer to the walls. The sealer will in turn bond to the resin in the Epiphany cones creating a monobloc that is designed to strengthen the root, resist leakage and entomb bacteria (Fig 3).

The most significant iteration in the obturation evolution continuum to date was the Continuous Wave of Obturation developed by Dr. L. Stephen Buchanan.[9] It eliminated the need to fit multiple pluggers and allowed for condensation of the gutta-percha in one downward compaction movement. A single tapered plugger is used to capture a wave of condensation at the orifice of a canal and to "ride it", without release to the apical extent of down packing in a single continuous movement. This builds a continuous wave of hydraulic forces that can push thermo-labile gutta-percha and sealer into anatomical irregularities and lateral canals. This is contrast to the Schilder technique where the wave is interrupted several times; the pressure wave and heat are lost each time condensation stops and the gutta-percha cools, which negatively impacts on the density of the fill.

FIGURE 5A—Regardless of the shaping and cleaning protocol used, the ability of any material to fill the root canal system is only as good as the degree of debridement and disinfection.

FIGURE 5B—The degree of hydraulics achieved with the THC technique is highly effective in the sealing of the myriad of portals of exit that communicate from arborizations of the root canal system into the surrounding peri-radicular attachment apparatus.

FIGURE 6—S-Kondensers—Double ended colour coded condensers—black 40 NiTi/80SS, yellow 50NiTi/100SS, blue 60NiTi/120SS

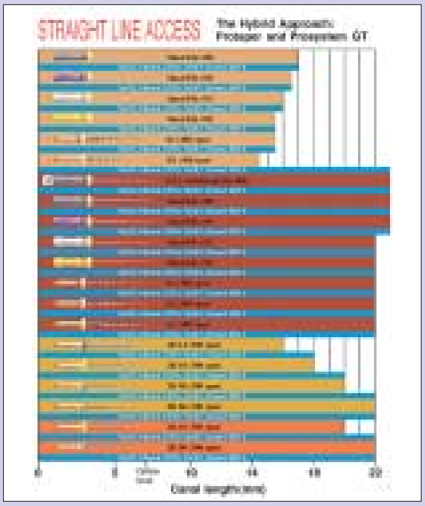
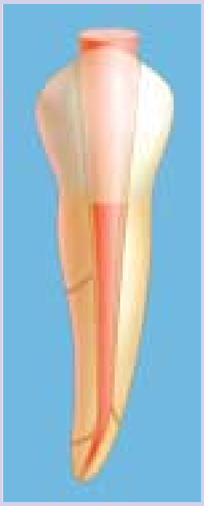


FIGURE 7—The hand and rotary instrumentation sequence in addition to the irrigation protocol and frequency of the Hybrid Approach using Protaper™ and ProSystemGT® Ni Ti instrumentation is diagrammed.



◄ **FIGURE 8**—The Hybrid Approach uses the ProSystemGT 20/.08 taper file as a standard for the minimum apical gauging instrument. This enables the clinician to fit a medium master resin-percha cone to the apical terminus of the canal preparation.

FIGURE 9—The dead soft Buchanan plugger is fit to its most apical point of descent in the root canal space. The continuum of tapered file, tapered plugger and tapered cone ensures an intimacy of fit that maximizes the hydraulic forces. The use of the Epiphany sealer facilitates true adhesion of the resin percha material to the radicular dentin. ►

The heat carriers or Buchanan pluggers of the System B Heat Source (Sybron Endo, Orange CA) technique (Fig. 4) were designed with geometries that closely approximate the shapes of tapered root canal preparations. These pluggers come in four sizes: fine, fine-medium, medium and medium-large which resemble the taper of non-standardized master cones. In addition, these dead-soft stainless steel heat carrier/plugger-condensers are flexible, allowing for deeper condensation especially in narrow, curved canals. The System B technique uses temperatures in the range of 200 to 300°C.

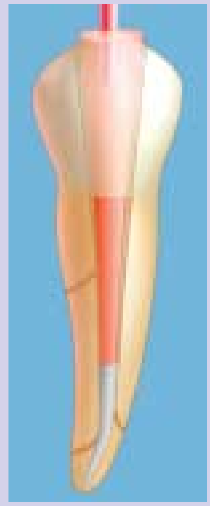
Resylon must be used at lower temperatures than required for effective application of the Continuous Wave Technique as taken to temperatures above 200°C, Resynol will become brittle when cooled and biodegrade. The optimum operating temperatures for Resynol with the Obtura II are; 20 gauge applicator tip—110 to 120°C, 23 gauge applicator tip—140°C, 25 gauge applicator tip—160°C.

The Thermo Hydraulic Condensation (THC) Technique[11] modifies the traditional System-B obturation protocol resulting in improved hydraulics during the down pack. The enhanced thermo-hydraulics from this technique results in filling a greater percentage of lateral canals and a more direct microstructural replication of the root canal space (Figs. 5A & B). In order to replicate the root canal system with the THC technique, certain parameters must be achieved: 1) the creation of a well defined apical control zone,[12] 2) the Epiphany cone chosen must fit intimately to the apically gauged foramenal terminus determined electronically, 3) the plugger, cone and canal shape must have an intimacy of fit, that 4) enables an S-Kondenser (Obtura/Spartan, Fenton MO) (Fig. 6) to fit within 4–6 mm from the working length.

The synergy created by combining the disparate design features of Protaper™ files and ProSystem GT® files has been described in a previous publication.[13] The geometries of each produce an excellent shaping contour in the root canal space and create a well defined apical control zone. Used in concert, the shaping achieved facilitates debridement, disinfection and microstructural replication in an unprecedented manner. The protocol sequence for the Hybrid Approach is demonstrated in Figure 7.

THE CENTERED CONTINUOUS WAVE DOWNPACK

A non-standardized (FM, M, ML) resin-percha cone is fitted to the electrometrically determined working length and then cut back .5 mm prior to the down pack since it will "skoot" a little with the sealer in place (Fig. 8). Once the cone has been fit and radiographically confirmed, the Continuous Wave (CW) plugger that matches the resin-percha cone used is fit in the canal (Fig. 8). The pluggers are available in sizes that correspond to both non-standardized and GT Shapes (F-.04, FM-.06, M-.08, ML-.10). The tips of these pluggers are all 0.5 mm in diameter and should fit within 4 mm to 6 mm from most canal termini (Fig. 9).



◄ **FIGURE 10A**—Activation of the Buchanan plugger sends a wave of heat coronal-apically through the resin-percha and simultaneously directs the force vectors of the material both vertically and laterally.

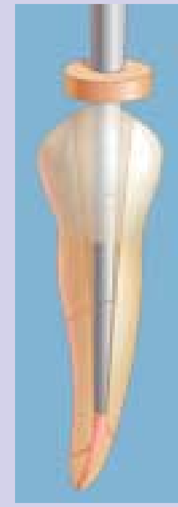
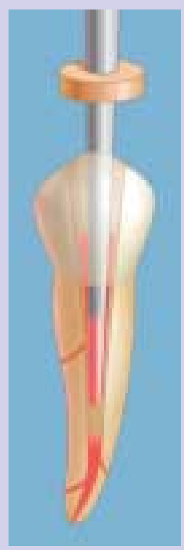


FIGURE 10B—The viscosity gradient of the material slows the descent of the plugger as the apical plug of resin-percha replicates the shape of the apical segment of the root canal space. The physical laws of nature apply; two objects cannot exist in the same space at the same time. ►



◄ **FIGURE 11**—The "separation burst" is initiated by raising the temperature of the System B Heat Source to 150°C. This change enables the remove the majority of the flash along the axial walls of the canal coronal to the apical plug established by the down pack. If excess material remains, it can be recompacted apically and the separation burst repeated.

FIGURE 12—An S-Kondenser is used to sustain vertical pressure on the apical plug of resin-percha for 10 seconds. This is necessary to ensure that volumetric shrinkage at the outer boundary of the material and the interface with the resin sealer is minimized as the central mass cools. ►

The final stage irrigation protocol, Smear Clear (Sybron Endo, Orange CA), NaOCl and ethanol, is used to ensure optimal debridement of the root canal system. The canal is then dried, the Epiphany Primer placed into the canal using the brushes provided, and the excess wicked out before inserting the sealer with paper points. The master cone is then minimally coated with the sealer before being seated passively to place.

The Obtura II™ (Obtura Spartan, Fenton MO) is set at 150°C and a bolus of resin-percha injected at the orifice level of the canal. The heat from the tip of the applicator needle will sear off the coronal portion of the cone and the approximately 2-3 mm of the resin-percha is condensed with a Schilder plugger slightly smaller than the orifice to create an orifice plug that will maximize the hydraulic pressure during the down pack.

The controls of the System B Heat Source are turned to the "use" and "touch" mode. The temperature is set to 100°C and the power on maximum. The omni-directional ring switch is activated and the heated plugger/condenser smoothly pistoned through the resin-percha to a depth of 3-4 mm from the predetermined binding point (Figs. 10A & B). Increasing resistance to the plugger penetration will occur and the tip may even stop as it molds its way down through the root canal space.

As the apical descent of the plugger tip is being arrested, the temperature on the System B is set to 150°C. Further apical pressure is used on the plugger to direct it to its binding point, and then it is quickly withdrawn. This "separation burst" will remove the majority of the flash along the axial walls of the canal coronal to the apical plug established by the down pack (Fig 11). An S-Kondenser prefitted to within 4-6 mm of working length is now used to further condense the resin-percha and applied apical pressure is sustained for 10 seconds to minimize shrinkage of the

◀ **FIGURE 13A**—Aliquots of resin-percha are deposited into the middle and coronal thirds from the Obtura II.

FIGURE 13B—The residual root canal space, lined with Epiphany sealer, is filled by compaction of the thermo-softened resin-percha. The authors recommend the use of the Ultra-Lume™ LED 2 (Ultradent Products, South Jordan UT) and the turbo tip lens to cure the coronal sealer material prior to post channel preparation. ▶

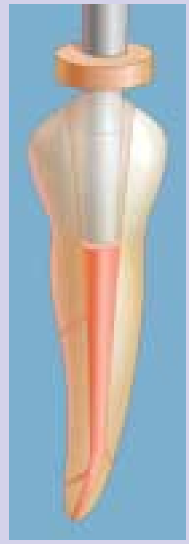


FIGURE 14—This clinical example of a complex and tortuous root canal system microstructurally replicated with the Epiphany Obturating System demonstrates the efficacy potential of both the THC technique and this new iteration in the armamentarium of endodontic space closure. (Courtesy of William Watson, DDS.)

material as it cools (Fig. 12).

The canal is now ready for backfill using the Obtura II. This can be accomplished by injecting small aliquots of resin-percha (2–3mm) into the canal and vertically compacting with a plugger (Figs. 13A & B). This is repeated until the root canal space is microstructurally replicated (Fig. 14). Post channel preparation, if required, is done only after the canal is first filled to the level of the orifice. It should also be noted that the Epiphany sealer is light curable and this can prove to be time efficient in the coronal aspect. The authors strongly advocate sealing the floor and orifice interface of dentin and resin-percha with a dentin adhesive and flowable composite to a depth of 1 mm if the case is not to be immediately restored with an intrachamber core complex.

The enhanced hydraulic pressures generated by the Thermo Hydraulic Condensation technique ensure the introduction of the primer/sealer/resin-percha complex into the micro-anatomy of the dentinal tubuli. In addition, this is done using temperatures that are significantly less than those of the classic System B Continuous Wave of Condensation Technique and therefore potentially less injurious to the attachment apparatus.

"Change is the constant, the signal for rebirth, the egg of the phoenix," (Christina Baldwin). The past decade has seen a significant majority of the endodontic armamentarium renewed or revolutionized. The residual element of this altered armamentarium, the material needed to fill and seal the root canal system, appears to have arisen from the laboratories of the scientists who effect clinical change. The adhesive monobloc may very well now extend from the coronal aspect of the tooth to the apical seal of the root(s). Endodontic success may indeed prove to be 100% predictable. **OH**

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Oral Health welcomes this original article.

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