The amazing complexities that pulpal systems possess can serve both as havens for bacterial colonization and portals for the extension of endodontic disease. Figure 1 is a cone beam computed tomography (CBCT) rendering of a lateral lesion of endodontic origin. As usual, the portal of exit from this diseased pulpal system is found in the center of the lesion. Many have documented the vast array of anatomical possibilities of pulpal systems, including the frequency of apical ramifications.1-4 Micro CT reconstruction is one way to visualize the randomness and beauty of pulpal systems. The micro CTs in Figures 2A-2D demonstrate varying apical pulpal anatomy of maxillary premolars.5 These illustrations do not depict special, unique, or rare pulpal anatomy. The rarity is the single, uncomplicated pulpal system. Clinical success is influenced by the capacity to three-dimensionally disinfect and seal these sophisticated internal caverns and terminations.4-6 Many recent technological advances facilitate high levels of shaping and disinfection of root canal systems. This article is the first in a series that examines the CORK system of obturation. The CORK technique comprehensively warms and softens apical gutta percha for simultaneous compaction and three-dimensional molding. Shown in Figure 3, the CORK delivery device consists of a thin silver carrier that partially wraps and extends the entire length of various apical shapes of gutta percha. This design provides several technological advantages. First, heat is transferred to all levels of the gutta percha directly through the silver. This overcomes gutta percha’s thermomechanical inability to transfer temperature more than a few millimeters.7-9 A precise and relatively uniform temperature is transferred throughout the apical gutta percha, resulting in even softening. In addition, the heat delivery is controlled such that phase transitions are avoided, thereby eliminating potential shrinkage problems.10 Secondly, three-dimensional molding occurs simultaneously as calibrated temperatures are achieved. This sequence of heat delivery and three-dimensional molding is followed by the removal of the delivery device and final three-dimensional molding, leaving a homogenous fill of gutta percha and sealer. Thirdly, the CORK design allows for confirmation of the position of the delivery device to the PDL with the use of an apex locator at the time of final placement. The CORK technique is illustrated in Figures 4A to 4D. Like a traditional master cone, a CORK delivery device that matches the final apical shape is fit (trimmed as needed), and sealer is applied. Apex locator confirmation of the final placement to the PDL is made. Heat is then applied at the top of the delivery device in a calibrated way producing ideal warmth of the entire apical gutta-percha cone. When ideal thermal conditions are met, simultaneous three-dimensional molding occurs. When the initial three-dimensional molding is complete, the delivery device is removed, leaving only homogenous gutta percha for a final wave of three-dimensional compaction. The result is a predictable,

**Figure 1:** CBCT evaluation displays the extension of endodontic disease from a lateral portal.

**Figures 2A to 2D:** In teeth that are commonly thought of as "single-rooted teeth," these micro CTs represent apical bifurcations, deltas, communications, and multiple ports of exit commonly present within premolars.

**Figure 3:** CORK delivery device. Note the apical gutta percha cone is partially wrapped in silver to facilitate a thorough temperature penetration to the apical end of the gutta percha. The design also allows for simultaneous molding of the apical gutta percha when precise heat is delivered as the attachment for heat delivery is at the top of the CORK delivery device. In addition, the design enables the use of an apex locator to gauge placement.

**Figure 4:** Like a traditional master cone, a CORK delivery device that matches the final apical shape is fit (trimmed as needed), and sealer is applied. Apex locator confirmation of the final placement to the PDL is made. Heat is then applied at the top of the delivery device in a calibrated way producing ideal warmth of the entire apical gutta-percha cone. When ideal thermal conditions are met, simultaneous three-dimensional molding occurs. When the initial three-dimensional molding is complete, the delivery device is removed, leaving only homogenous gutta percha for a final wave of three-dimensional compaction. The result is a predictable,

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**3D Apical Cork – Part 1**

Dr. Wyatt Simons explains the basics of the CORK technique.

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**TECHNOLOGY**
Figure 4: CORK technique. 1. Fit a CORK delivery device that matches the final apical shape. Trim as needed based on apex locator feedback. 2. Attach heat source to the top of the CORK delivery device. 3. Calibrate a precise, relatively even heat delivery to the entire apical gutta percha. 4. 3-dimensionally mold the softened apical gutta percha. 5. Remove the delivery device, and complete the 3-dimensional compaction of the homogenous gutta percha, resulting in the canal CORKed.

Figure 5A: As shown in the graph above, the CORK system establishes substantially uniform thermal conditions at all levels of the gutta percha. The apical gutta percha is held at 40-42º C.

Figure 5B-C: Intracanal thermocouples at D1, D3, and D6 illustrate the ability of the CORK delivery device to establish and control ideal warmth of gutta percha.

Figure 5D: As shown in this graph, even deep penetration of conventional heat sources can be random and inadequate in many clinical situations.

Figure 5E-F: Although gutta percha can accept direct heat well, its thermomechanical properties are such that the ability to transfer heat is limited.

Figure 6A: CORK fit. Final placement of the CORK delivery device was confirmed with the use of an apex locator. Safe, apical cork of the root canal system.

In vitro tests were done on the CORK delivery device to validate and refine precise heat transfer to all levels of gutta percha. Heat penetration was recorded with thermocouples placed flush to internal canal walls. As shown in this series of images (Figures 5A-5D), the CORK technique produces a relatively uniform warming of apical gutta percha. In contrast, the known limitation of a gutta-percha master cone to transfer temperature is displayed.

The CORK technique is able to accomplish this level of temperature penetration by wrapping the apical gutta-percha cone in the thermoconductive, removable delivery device. The delivery device provides a calibrated, direct heat transfer to the gutta percha at all levels. In addition, the design allows for the temperature absorption of the gutta percha to stay below phase transition temperatures at all levels. This allows softening for three-dimensional molding, while eliminating the potential for shrinkage. Furthermore, it has been shown that when gutta percha is heated for molding, but phase transitions are not reached, a 1% expansion may occur.

Figures 6A-6C illustrate a clinical CORK case. This 92-year-old patient presented with a mandibular second premolar that had a fairly large lesion of endodontic origin. It was an integral part of the double abutment at the anterior end of this patient’s five-unit bridge. After shaping and disinfection, the CORK delivery device was able to gauge a favorable, accurate, final position at the terminus (Figure 6A). In this case, the delivery device was snipped twice based on feedback by the apex locator as to its position at the large and possibly resorbed apical foramen. When the desired reading of a 1/4 mm from the PDL was accomplished, heat was applied to the delivery device in a calibrated way. When the delivery device produced a consistent,
A thorough apical temperature of 40 – 42°C, the initial phase of three-dimensional molding was done. At these temperatures, gutta percha exists at a softened and moldable state. When gutta percha is heated at higher temperatures, it becomes runny and sticky. In contrast, the gutta percha in this case was held at favorable temperatures for molding along its entire length while initial three-dimensional compaction occurred. Finally, while temperature was held constant, the delivery device was seamlessly removed, and final apical compaction was completed (Figure 6B). Good osseous healing was achieved as noted when the 93-year old patient returned for her 1-year recall (Figure 6C).

The CORK system and technique were utilized to three-dimensionally obturate the maxillary second premolar shown in Figure 7A. The CORK delivery device was able to establish conditions that allowed for three-dimensional filling of the apical branching found in this case. The micro CT reconstruction displayed in Figure 7B highlights this common branching of pulpal systems.

Figures 8A-8F illustrate a clinical case in which the CORK delivery device facilitated ease of placement and heat delivery to deep regions of the complex pulpal anatomy encountered. The ability to deliver heat to the apical end of this maxillary second molar’s long, curved roots can be difficult, if not deficient, with conventional techniques. Once disinfected and dried, the CORK delivery device was pre-curved for ease in negotiating the severe curvature. Upon confirmation of the final placement with the apex locator, heat was applied to delivery device. As the desired temperature reached all levels of the apical...
gutta percha, the first wave of compaction provided initial three-dimensional molding, followed by removal of the delivery device and final three-dimensional compaction. Each canal was safely, accurately, and thoroughly corked with this technique, and the remaining canal was backfilled to desired levels.

Closing comments:
The endodontic profession has been the beneficiary of great leaders and monumental advances over the years. From microscopes and CBCT imaging to revolutionary shaping files and disinfection systems, our ability to obtain many well-established objectives for success has increased exponentially. Breakthroughs in diagnosis, shaping, and disinfection have opened a new frontier in conservatively tackling the complexities of pulpal anatomy. We are empowered to mindfully, and successfully shape and disinfect the vast array of anatomical possibilities present. We respect the reality of pulpal anatomy and endodontic disease, yet we are exhilarated by the challenge that difficult pulpal anatomy poses. The preoperative lateral radiolucency or fistula that traces to a mid-root lesion excites us; it doesn’t concern us. This type of enthusiasm is what inspired the progressive development of the CORK system of obturation. The potential to fill all portals that feed our patient’s infection is thrilling. With the advances in shaping and disinfection, it is only logical to push forward on improvements and controls around our objective to three-dimensionally seal disinfected root canal systems. Technological improvements in obturation will help in our pursuit to master our craft. Our commitment to continue to provide successful outcomes will enable us to stay at the front of the list when it comes to treatment options for our patients.

Future articles in this series will discuss the CORK technique in more detail with emphasis given to clinical examples of the benefits of this system of obturation. The revolutionary 3D plugger, which conforms to individual canal anatomy as it moves within the canal, will be introduced. Benefits of the new forces of compaction created and how they relate to molding will be discussed.