Bioceramics Part I: The Clinician's Viewpoint

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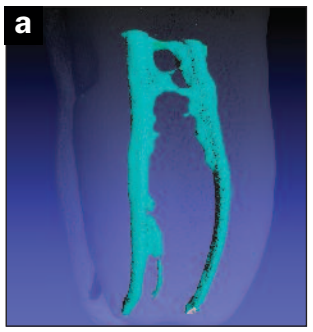
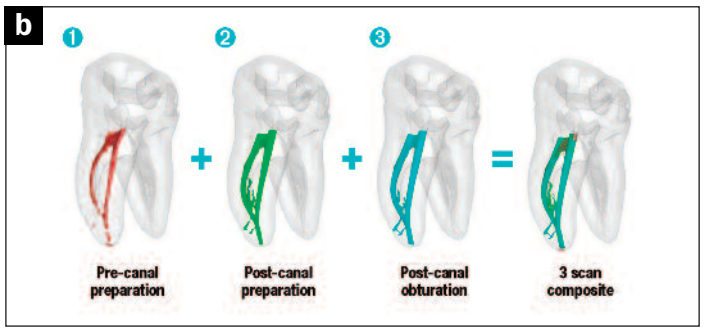
Figure 1. EndoSequence BC Sealer (Brasseler USA) in a syringe.





Figures 2a and b. (a) You can see from this image the excellent adaption of the bioceramic sealer (and gutta-percha) to the true shape of the prepared canal. **(b)** Four image composite: Here we can see the remarkable flowability of the BC Sealer. This is a result of its particle size and hydrophilicity. (*Courtesy of Dr. Adam Lloyd, Germantown, Tenn*)

This, and all future articles that are presented in multiple parts, are available to our readers at our Web site, dentistrytoday.com.

It has been nearly 2 years since we introduced bioceramics to endodontics and the news just keeps getting better and better. It now seems that there are multiple applications in dentistry, not just endodontics, for this technology and we want to share this excitement with you in a 2-part series.

Part 1 will be a quick review of some of the key physical properties of bioceramics and how to properly use it in nonsurgical cases. In addition to providing some "tips" on working with this material, we will also share various clinicians' viewpoints on how this material (and technique) works for them in their practice. Part 2 will concentrate on a review of the science (both old and new) along with multiple surgical applications.

KEY PHYSICAL PROPERTIES

The first question we must ask ourselves is why has there been so much excitement associated with the expanded use of bioceramics in endodontics? Clearly the first answer is related to physical properties. Bioceramics are exceedingly biocompatible (nontoxic) and they are chemically stable within the biological environment. Also, bioceramics do not shrink upon setting. In fact, they actually expand slightly upon completion of the setting process (0.002). Furthermore (and this is very important in endodontics), bioceramics will not result in a significant inflammatory response if an overfill occurs during the obturation process or in a root repair. These are all outstanding properties for any sealer. A further advantage of the material itself is its ability (during the setting process) to form hydroxyapatite and ultimately establish a chemical bond between dentin and the appropriate filling materials...in essence, a bonded restoration.

Figure 3. BC Cones/ paper point organizer.

But, what is it specifically about bioceramics that make them so well-suited to act as a sealer? From our perspective as endodontists, some of the advantages are: high pH (12.8) during the initial 24 hours of the setting process (which is strongly antibacterial) hydrophilic nature, not hydrophobic, enhanced biocompatibility, does not shrink, does not resorb (which is critical for a sealer based technique), excellent sealing ability, sets quickly (3 to 4 hours) and its ease of use (particle size is so small it can be used in a syringe).

The introduction of a bioceramic sealer (EndoSequence BC Sealer [Brasseler USA]) allows us, for the first time, to take advantage of all the benefits associated with bioceramics but to not limit its use to merely root repairs and apical retrofills. This is only possible because of recent nanotechnology developments; the particle size of BC Sealer is so fine (less than 2 µm), it can actually be used with a .012 capillary tip.

This material has been specifically designed as a nontoxic calcium silicate cement that is easy to use as an endodontic sealer. This is a key point. In addition to its excellent physical properties, the purpose of BC Sealer is to improve the convenience and delivery method of an excellent root canal sealer while simultaneously taking advantage of its bioactive characteristics (it utilizes the water inherent in the dentinal tubules to drive the hydration reaction of the material, thereby shortening the setting time). As we know, dentin is composed of approximately 20% (by volume) water; and it is this water that initiates the setting of the material and ultimately results in the formation of hydroxyapatite. Therefore, if any residual moisture remains in the canal after drying, it will not adversely affect the seal established by the bioceramic cement. This is very important in obturation and is a major improvement over previous sealers. Furthermore, its hydrophilicity, small particle size, and chemical bonding to the canals' walls makes for excellent hydraulics.[1]

continued on page xx

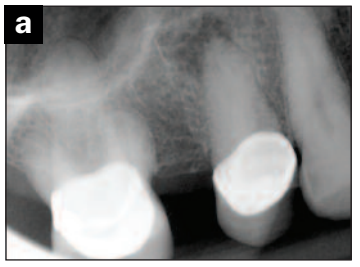



Figures 4a to 4d. (a and b) Post space created by EndoSequence file (Brasseler USA). **(c and d)** Three-year recall after post cementation. (*Courtesy of Dr. Ali Nasseh, Boston, Mass*)


Figures 5a and 5b. (a) Original pre-op x-ray. **(b)** Three-year recall. (*Courtesy of Dr. Ali Nasseh, Boston, Mass*)



Figures 6a to 6c. (a) Mandibular second molar pre-op x-ray. **(b)** Mandibular second molar immediate post-op x-ray. **(c)** Mandibular second molar recall x-ray. (*Courtesy of Dr. Nadar Vafaie, Novato, Calif*)




Figures 7a and 7b. (a) Maxillary premolar pre-op x-ray. **(b)** Maxillary premolar post-op x-ray. (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

Bioceramics Part 1...

continued from page 00

One of the best aspects of using the EndoSequence technique (and possibly the least discussed) is the dramatic increase in office profitability seen as the result of its efficiency. This increase in productivity applies to both endodontic practices as well as the general practice. But what is it about EndoSequence that can lead to such a dramatic increase in productivity? Let's begin by examining the technique itself.

It all begins with the file. To be more specific, it all begins with the preparation created by the file...a constant taper preparation. When using the EndoSequence technique, we can create either a .04 constant taper preparation or a .06 taper one. The real key is the constant taper preparation because when accomplished, it now gives us the ability to create predictable, reproducible shapes. A variable taper preparation is not recommended because its lack of shaping predictability (and its corresponding lack of reproducibility) will lead to a less than ideal master conefit. This lack of endodontic synchronicity is why all variable taper preparations are associated with overly expensive and more time consuming thermoplastic techniques.

Knowing in advance what the final shape (constant taper preparation) will be is a great time saver. Then add in the feature of laser verified paper points and gutta-percha cones, and we now start to develop true endodontic synchronicity (everything matches).

This concept of having everything match is so important because it allows us, for the first time, to perform rotary endodontics in a truly conservative fashion and to be able to use a hydraulic condensation technique. Furthermore, when used in conjunction with the EndoSequence filing system, this becomes a *synchronized hydraulic condensation technique*. This has tremendous implications for the tooth as evidenced by a recent study, "Resistance to Fracture of Roots Obturated with Novel Canal-filling Systems," published in 2011 in the *Journal of Endodontics*.[2] The purpose of this study was to evaluate and compare the fracture resistance of roots obturated with various contemporary canal-filling systems. The investigators (Ghoneim et al) instrumented 40 single canal premolars using 0.06 taper EndoSequence files (Brasseler USA). The teeth were then obturated using 4 different techniques: Group 1 used a bioceramic sealer (iRoot SP [iRoot SP sealer is BC Sealer in Europe]) in combination with ActiV GP cones (Brasseler USA) while group 2 used the bioceramic sealer with regular gutta-percha cones. Group 3 utilized ActiV GP sealer plus ActiV GP cones, and group 4 employed ActiV GP sealer with conventional gutta-percha cones. All 4 groups were obturated using a single-cone technique. Ten teeth were left unprepared and these acted as a negative control for the study.

Following preparation and obturation, all the teeth were embedded in acrylic molds and then subjected to the fracture resistance test in which a compressive loading (0.5 mm/min) was applied until fracture. Subsequently, all data was statistically analyzed utilizing the analysis of variance model and the Tukey *post hoc* test.

The results generated were quite remarkable. It was demonstrated that the *significantly highest fracture resistance* was recorded for both the negative control group and group 1 (bioceramic sealer [iRoot SP]/ActiV GP cone) with no statistically significant difference between them. The lowest reported value was in group 4, which employed ActiV GP sealer in combination with regular gutta-percha. The conclusion of this study was that employing a bioceramic-based sealer (such as BC Sealer or iRoot SP) is very promising in terms of strengthening the root and increasing the *in vitro* fracture resistance of endodontically treated teeth. This is a very significant finding especially regarding the long-term retention of an endodontically treated tooth.

In this particular study, the bioceramic sealer performed best when accompanied with ActiV GP cones. In fact, bonding will occur between the bioceramic sealer and the ceramic particles in the ActiV GP cones as well as to the bioceramic particles present in BC gutta-percha. For those unfamiliar with the hydraulic condensation technique, it is as follows.[3]

SYNCHRONIZED HYDRAULIC CONDENSATION

The technique with this material is quite straightforward. Simply remove the syringe cap from the EndoSequence BC Sealer syringe (Figure 1). Then attach an Intra Canal Tip of your choice to the hub of the syringe. The Intra Canal Tip is flexible and can be bent to facilitate access to the root canal. Also, because the particle size has been milled to such a fine size (less than 2 µm), a capillary tip (such as a .012) can be used to place the sealer.

Following this procedure, insert the tip of the syringe into the canal no deeper than the coronal one third. Gently and smoothly dispense a small amount of EndoSequence BC Sealer into the root canal by compressing the plunger of the syringe. Then remove the disposable tip from the syringe and proceed to coat the master gutta-percha cone with a thin layer of sealer. After the cone has been lightly coated, slowly insert it into the canal all the way to the final working length. The synchronized master gutta-percha cone will carry sufficient material to seal the apex.

The precise fit of the EndoSequence gutta-percha master cone (in combination with a constant taper preparation) creates excellent hydraulics and, for that reason, it is recommended that the practitioner use only a small amount of sealer. Furthermore, as with all obturation techniques, it is important to insert the master cone slowly to its final working length. Finally, here's more good news: the EndoSequence System is now available with bioceramic coated

continued on page xx

Bioceramics Part 1...

continued from page 00

gutta-percha cones. So in essence, what we achieve is a chemical bond to the canal wall as a result of the hydroxyapatite that is created during the setting reaction of the bioceramic material, and we also have a chemical bond between the ceramic particles in the sealer and the ceramic particles in/on the bioceramic coated cone.

Think about what we have just accomplished; we are now doing root canals in a manner that truly is easier, faster, and better. This is not just marketing hype, but actuality. As further evidence of this technique, we asked Dr. Adam Lloyd, the chairman of the Department of Endodontics at the University of Tennessee (UT) to share the results of a study recently conducted at UT. A synopsis of this study and the findings follows.

MATERIALS & METHODS

Sixteen recently extracted human molars were mounted on individual stubs and underwent an initial high spatial resolution computed tomography scan prior to any treatment. Following biomechanical crown-down canal preparation to an apical matrix of 35/.04 and ultrasonic irrigation with 6% sodium hypochlorite, each sample was scanned a second time. Obturation was completed using a single matched gutta-percha cone and EndoSequence BC sealer. The coronal 4 mm of the gutta-percha was thermosoftened and compacted vertically. Subsequent to canal obturation, a third scan was made.

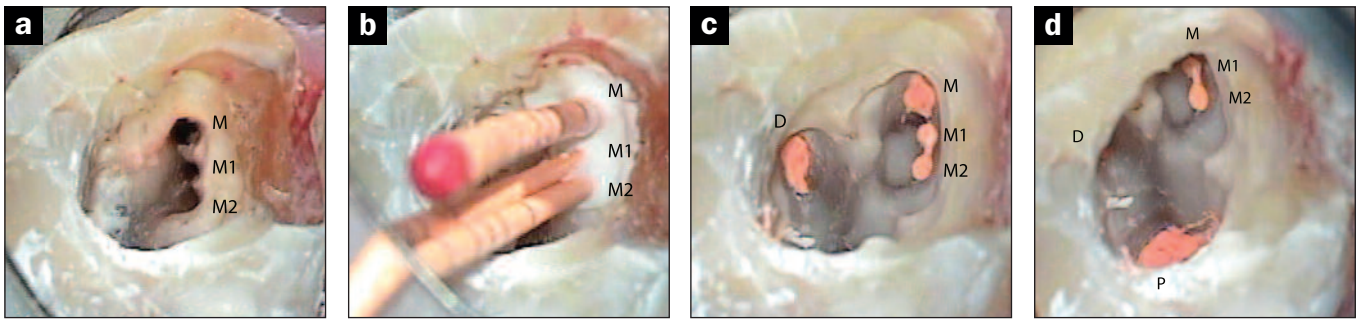
Scanning of the specimens was performed (Actis 150/130, Varian Medical Systems, Palo Alto, Calif) with a 180° rotation around the vertical axis and a single rotation step of 0.9° with a cross-sectional pixel size of approximately 24 µm. All 3 backscatter projections were aligned post-processing with sub-voxel accuracy at 92% CI in VG Studio Max 2.1 (Volume Graphics GmbH) and manipulated to create regions of interest for each of the scans.

RESULTS

Analysis of volume occupied by sealer in relation to total original canal volumes was found to be extremely high with a mean of 97%, ± 2.8, much higher than reported previously using studies on canal surface area occupancy of material, with 75% of samples occupied at the ≥ 95% level (Figures 2a and 2b).

FIVE TIPS FOR USING A BIOCERAMIC SEALER

Tip No. 1: Do Not Store in a Refrigerator



Figures 8a and 8b. (a) Microscopic evaluation: located 3 mesial canals (M, M1, and M2). **(b)** Bioceramic seal of M, M1, and M2 canals. (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

Figures 8c and 8d. Microscopic evaluation of pulpal floor; removal of decay/no crack observed–canal sealed with bioceramic sealer (BC Sealer). (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

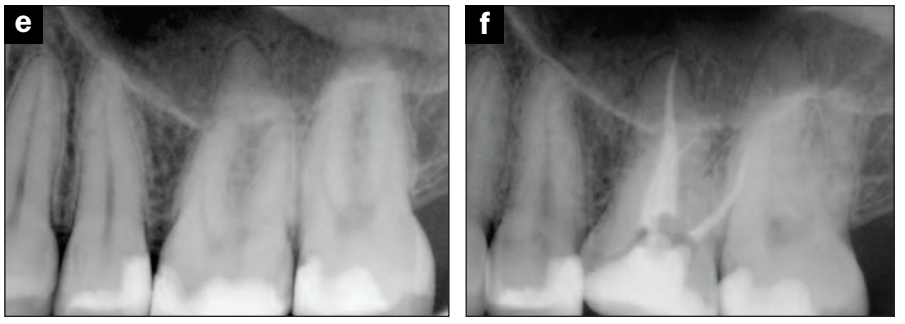


Figure 8e. Mandibular molar pre-op x-ray. (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

Figure 8f. Post-op x-ray of Dr. Gatti's case. (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

EndoSequence BC Sealer comes premixed in a syringe, which does not have to be stored in a refrigerator. In fact, since it is the moisture inherent in the dentinal tubules which initiates the setting reaction, it is strongly recommended *not* to keep it in a refrigerator. Room temperature is perfectly fine.

Tip No. 2: New Users Do Not Have to Place the Syringe Into the Canal

Those clinicians just beginning to use BC Sealer may be wise to do a few cases where you simply syringe the material onto a glass slab, lightly coat the primary cone with the sealer, and then use the cone to deliver the sealer into the canal (lightly coating the walls with BC Sealer). Naturally, this specific method is like any other sealer technique but after 2 or more cases, you should get a feel for how well the bioceramic sealer flows. BC Sealer flows much better than conventional sealers and this is due to its small particle size (less than 2 µm).

Tip No. 3: Don't Use too Much Sealer

Too often we see clinicians use too much sealer when performing obturation. This is true for any obturation method. The same thing applies for bioceramics. When using the premixed syringe to deliver the sealer, go slowly down into the canal no more than one third of the way and then deliver only a modest amount of sealer. When using the premixed syringe to deliver the BC Sealer, we like to take the disposable tip off the syringe (after delivering the sealer into the canal) and then coat the master cone (with the sealer) by simply placing it into the tip. This will not only coat the master cone very nicely, it will also minimize the waste of excess sealer.

Tip No. 4: Use Bioceramic Coated Cones

The aim of the entire EndoSequence technique is to have a cone precisely match the canal preparation and to then have this cone deliver the bioceramic sealer into the canal space, which creates the seal. Gutta-percha does not create a seal; it just takes up space. The sealer is what creates the seal! To take full advantage of the bond that is created by the bioceramic glass particles, we recommend the new bioceramic coated gutta-percha cones (BC gutta-percha). A glass ionomer coated cone will also work, but the bioceramic coated cones are even better. The bioceramic cones are also a little stiffer and easier to work with, in our opinion (Figure 3).

Tip No. 5: Advanced Obturation Technique With Bioceramics

This is a tip from Dr. Ali Nasseh (Boston, Mass) who has performed more than 3,500 bioceramic procedures (both surgical and nonsurgical). In Dr. Nasseh's words:[4]

"In canals where the final prepared shape is round enough so that the master gutta-percha cone is in very close proximity to the prepared canal walls, inject a small dollop of the bioceramic sealer into the canal and then take your EndoSequence Master Apical File (eg, if size 40/.04 is the final instrumented size and a 40/.04 GP master cone has been verified to fit) and place it into the canal by hand (do not use a handpiece). While inserting the file into the canal, slightly turn it in a counterclockwise manner, so that the sealer is carried down with the file, as opposed to simply filling the flutes. Generally, one 360° rotation for the full length of the canal should be enough. Once the file reaches its apical termination, remove it from the canal with an additional counterclockwise motion. This action takes the sealer that was placed in the canal and simply spreads it against the walls. (Any excess sealer will fill in the flutes of the file.) Then you may simply coat the master cone with some sealer and gently insert it into the canal.

"Particularly noteworthy, with this technique, is that this action of placing a file into the canal (prior to obturation) helps to remove any excessive hydraulic force that may cause either sealer extrusion or trapping of the sealer under the cone (in the case of a closed apex) that may ultimately prevent the full seating of the master cone. It is also important to note that the reinsertion of the master apical file into a canal that has been previously disinfected with our final disinfection protocol is only made possible if this file has been wiped thoroughly with an alcohol gauze pad and properly disinfected. Reinsertion of a contaminated file into the canal just prior to obturation in not proper aseptic practice."

As further evidence of the benefits of this technique, let's examine some of Dr. Nasseh's cases.

Case 1—The patient presented with no posterior support (edentulous in the posterior region) and had severe attrition on the lingual aspect of all anterior teeth. The pulps literally could be seen on these anterior teeth. The referring prosthodontist requested endodontic treatment (on these teeth) prior to restoration. All 6

continued on page xx

Bioceramics Part 1...

continued from page 00

teeth were treated endodontically in one visit (2 hours!) and post spaces were prepared and fitted with the EndoSequence fiber post system (Brasseler USA). Three year post operative radiographs show the maintenance of periapical health in all teeth with cemented posts and fabricated crowns (Figures 4a to 4d).

Case 2—This patient was one of the original cases of BC Sealer obturation. A 3-year follow up of this case shows great healing and maintenance of the periapical area given the presence of lateral and accessory canals (Figures 5a and 5b).

Now that we have reviewed the salient aspects of BC Sealer and it associated properties, along with viewing some of Dr. Nasseh's cases, let's hear what some other noted clinicians have to say about it, in their own words.

The first endodontist we asked to share his opinion is Dr. Nader Vafaie of Novato, Calif (oral communication, September 2011).

When we look at all the advances in dentistry in recent years, including new generation bonding materials, rotary instrumentation for root canal therapy, and the use of the microscope in treating root canals, there is no doubt that we are providing a better treatment outcome to our patients with better than ever success rates. When you factor in more conservative approaches in the way we instrument and restore teeth, we are compounding the long-term favorable outcomes and reducing our failures in every capacity.

As I arrive to work each day, I am reminded of the ease with which I can continue to practice because of these advances. There is less mixing chairside, there is more efficiency in the way we move through our instrument sequences, and my posture is greatly improved thanks to the scope. Patients are thrilled and I am happier. One of the most recent advances (that I have incorporated into my practice, that was the missing link in endodontics) is the bioceramic sealer by Brasseler USA. In essence it is like having liquid MTA at your finger tips. It far exceeds other sealers in ease of use and what the sealer is designed to do. Let's look back at the function of sealers for a second, and that is to "seal" the canal space. But is it really about the seal? Not really; nothing is perfectly sealed in dentistry. If bacteria want to make it in, they will. That being said, it is imperative that we perform procedures in as aseptic a manner as possible and use materials that make it really hard for them to get in and reinfect or cause decay.

That's where I rely on the strengths of the BC sealer. It sets at a high Ph so bacteria don't like to aggregate around it and the gutta-percha sealer interface as well as the sealer root interface is, shall we say, more difficult to penetrate. In addition it is highly biologically compatible, so if there is the occasional overfill I am not as worried about the case. The best part of this sealer, at least clinically, is the ease by which it cleans up from inside the pulp chamber. A little water in combination with ultrasonics leaves the chamber ultra clean. I have incorporated the sealer and the paste into all aspects of my treatments, from surgical repairs to apicoectomies and even tooth reimplantations (Figures 6a to 6c).

Too often we see clinicians use too much sealer when performing obturation. This is true for any obturation method. The same thing applies for bioceramics.

Another skilled endodontist, Dr John Gatti of Lee's Summit, Mo, has also been using the bioceramics with great success. Here are 3 cases (and commentary) from Dr. Gatti (oral communication, September 2011).

The progression in endodontics from hand filing to the use of nickel titanium rotary instrumentation was not only a tremendous advantage in the way in which teeth were endodontically treated, but a true advancement for the health of the patient. The ability to thoroughly clean the root canal system was now becoming the norm. However, the long-term success of root canal treatment still remains today not only dependent upon the removal of bacterial colonies, but sustaining the infected free environment of the root canal system. Bacteria are the main cause of re-infection of a root canal system which can enter through saliva or the tooth micro-circulation in the blood system. Once bacteria finds a place of adherence, the virulence of the organism strengthens. The breakdown of the root canal filling usually fails at the union of the core material, gutta-percha, and the sealer.

The advancement in bioceramic technology has changed the way endodontics is performed, and has thoroughly enhanced the treatment outcomes for patients. Since the primary goal of endodontics is the eradication of bacteria, the high PH (or very basic nature of the bio-ceramic sealer) has allowed post-operative discomfort to be so minimal that what used to be an irritant is now an indirect form of palliative treatment. As the sealing material sets, the formation of hydroxyapatite allows a biocompatible bond with the surrounding bone matrix. The ability to manipulate the sealer using hydraulic condensation as a vehicle to strategically place the sealer is a tremendous advantage of the material.

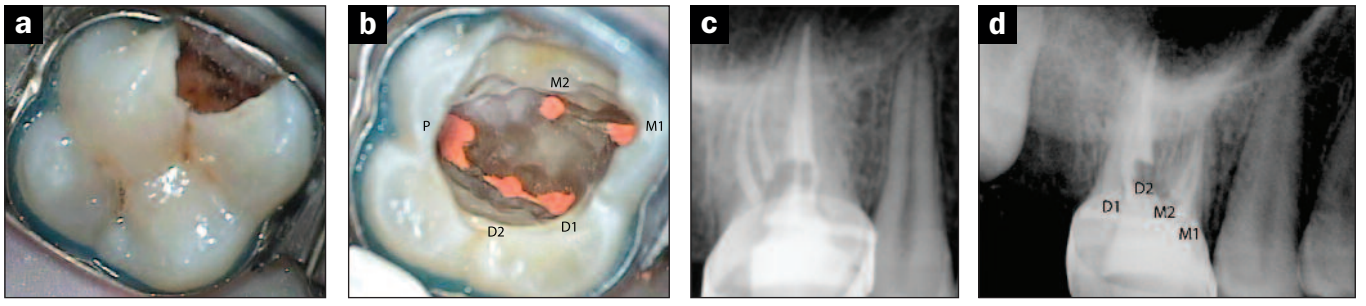


Figure 9a to 9c. (a) Initial appearance; gross decay. **(b)** Microscopic evaluation of pulpal floor; removal of decay/no crack observed–canal sealed with bioceramic sealer (BC Sealer). **(c)** Radiograph showing separation of M1, M2, D1, and D2 canals. **(d)** X-ray of maxillary molar with 5 canals. (*Courtesy of Dr. John Gatti, Lee's Summit, Mo*)

Case 1—A symptomatic severely calcified maxillary premolar presented necrotic with pathology. Upon conservative access, the wishbone canal configuration was thoroughly cleansed and obturated with bioceramic sealer using hydraulic condensation. The entire canal system was treated without the need for over-instrumentation to obtain an adequate seal. Remarkably, the patient reported minimal symptoms 24 hours postoperative. (Figures 7a and 7b).

Case 2—An acute pulpitis of a maxillary molar is treated, taking advantage of the bioceramic abilities and the hydraulic condensation technique. Due to the 5 canal configuration of this molar, all 3 canals of the mesial root were able to be obturated at the same time. Other obturation techniques would have made filling this canal system more difficult than necessary. The ability of the bioceramic sealer to be placed with ample working time allows for a true 3-dimensional sealing of the canal system. The patient reported no symptoms 24 hours postoperative (Figures 8a to8f).

Case 3—A severely decayed acute pulpitis of a maxillary molar. This case also exhibits 5 canals, but brings a different challenge than the case above. The canal webbing is very apparent in the canal configuration of 2 distal canals. The canal communication is seen anastomosed between both distal canals as well as the palatal canal. Again, taking advantage of the bioceramic abilities and the hydraulic condensation technique, this 5 canal molar is treated with relative ease. A major component for the success of this case is the conservative preparation of each canal, while maintaining true canal anatomy. It is apparent the microscopic and radiographic visuals support the thorough and complete treatment of this case (Figures 9a to 9d). Obturation was dictated by the original canal anatomy rather than unnecessary removal of canal dentin. The patient reported no symptoms 24 hours postoperative.

So, there it is. What we have demonstrated in this first of 2 articles is not just a review of the salient properties of bioceramics but, more importantly, how it has performed for practicing endodontists. Whether you do one hundred cases a year or one thousand cases a year, you need to seriously consider this material and technique. Both you and your patient will be glad you did! ✦

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Dr. Koch is the founder and past director of

continued on page xx

Bioceramics Part 1...

continued from page 00

the new program in postdoctoral endodontics at the Harvard School of Dental Medicine. In addition to having maintained a private practice limited to endodontics, he has written numerous articles on endodontics and he lecturers worldwide. He is a cofounder of Real World Endo. He can be reached at realworldendo.com.

Dr. Brave is a Diplomate of the American Board of Endodontics and is a member of the College of Diplomates. In endodontic practice for more than 25 years, he has lectured extensively on endodontics and holds several patents, including the VisiFrame. Formerly an associate clinical professor at the University of Pennsylvania, Dr. Brave currently holds a staff position at the Johns Hopkins Hospital. He is a cofounder of Real World Endo. He can be reached at realworldendo.com.

Disclosures: Drs. Koch and Brave are cofounders of Real World Endo and are the developers of the EndoSequence System.

continued on page xx