**Bioceramic Technology – the game changer in endodontics**

**An Update in 2019**

When Real World Endo and Brasseler USA first introduced bioceramic technology to the dental world we expected an initial resistance due to practicing endodontists’ native resistance to change sealers but ultimately, we expected a very positive response that would increase over time. Now (at its approximate tenth-year anniversary) it is indeed an appropriate time to review the impact of its introduction and how it has changed both surgical and non-surgical endodontics.

At the time of its introduction, bioceramic technology faced competition as an endodontic sealer from both glass ionomer and epoxy resin cements. While both sealers had their advocates and advantages, they each had limitations. Epoxy resins demonstrated a bond to gutta percha but had no bond to the canal wall. Glass ionomer had an excellent bond to the canal wall but displayed no attachment to the gutta percha.

Real World Endo in its search for a “mono block” addressed this challenge in an orchestrated fashion. First, we changed the molecular density of gutta percha to make it stiffer (Galaxy gutta percha). Then we developed a surfactant enhanced EDTA solution (SmearClear-SybronEndo) that opened the dentinal tubules in such a way that we could easily bond to the canal walls. Subsequently, we created ActiVGP (Brasseler USA) which was an obturation system that utilized glass ionomer in combination with laser verified gutta percha cones. ActiV GP cones were impregnated with glass ionomer particles and then additionally coated with extremely fine glass ionomer particles at a thickness of one micron. With the introduction of ActiV GP, we were now entering the world of nano-technology. ActiV GP was the precursor to the currently used bioceramic technique of hydraulic condensation.

Bioceramic technology and the science associated with such is the basis of EndoSequence BC Sealer. But before we discuss how this specific sealer has changed and is still changing obturation, we need to address some of the merits associated with bioceramics. The first question we need to ask ourselves is, “What are bioceramics?” Indeed, bioceramics are ceramic materials specifically designed for use in medicine and dentistry. They include alumina and zirconia, bioactive glass, glass ceramics, hydroxyapatite, and resorbable calcium phosphates. There are numerous bioceramics currently in use in both dentistry and medicine, although more so in medicine. Alumina and zirconia are among the most popular bioinert ceramics used for prosthetic devices associated with surgical cases. Furthermore, bioactive glasses and glass ceramics are available for use in dentistry under various trade names. Additionally, porous ceramics such as calcium phosphate based materials have been used for filling bone defects. Even some very basic calcium silicates such as ProRoot MTA (Dentsply) have been used successfully in dentistry as a root repair material and for apical retrofills.

However, we must ask ourselves another more specific question. “What are the advantages of bioceramics in dental applications?” Clearly the answer is related to its physical properties. Bioceramics are exceedingly biocompatible, non-toxic, do not shrink upon setting, are hydrophilic not hydrophobic and are chemically stable within the biological environment. Secondly (and this is very important in endodontics) bioceramics will produce little, if any, inflammatory response if an over-fill occurs during the obturation process or during a root repair. A further advantage of the material itself is its ability (during the setting process) to form hydroxyapatite and ultimately a bond between dentin and filling materials. Because of its ability to generate hydroxyapatite during its hydration reaction, we like to think of bioceramics like a bone cement.

While the properties associated with bioceramics make them very attractive to dentistry, in general, what would be their advantage if used as an endodontic sealer? From our perspective as endodontists, some of the advantages are: enhanced biocompatibility, possible increased strength of the root following obturation, high pH (12.8) during the setting process which is strongly anti-bacterial, sealing ability and its ease of use.

The introduction of EndoSequence BC Sealer allowed 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 was possible because of smart nanotechnology developments; the particle size of BC sealer (less than one micron) is so fine, it can actually be used with a .014 capillary tip. When viewed in the overall context of obturation techniques, EndoSequence BC Sealer has been and continues to be a game changer.

Furthermore, this material has been designed as a non-toxic calcium phosphate silicate cement that is easy to use as an endodontic sealer. 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. BC Sealer utilizes the water inherent in the dentinal tubules to drive the hydration reaction of the material thereby shortening the setting time. Dentin is composed of approximately 20-30% (by volume) water and it is this water which initiates the setting reaction of the material and ultimately results in the formation of hydroxyapatite.

**EndoSequence BC Sealer setting reactions**

The calcium silicates in the powder hydrate to produce a calcium silicate hydrate gel and calcium hydroxide. The calcium hydroxide then reacts with the phosphate ions to precipitate hydroxyapatite and water. This is a classic hydration reaction. The water continues to react with the calcium silicates to precipitate additional gel-like calcium silicate hydrate. The water generated through this reaction is an important factor in controlling the hydration rate and the setting time as follows: The hydration reactions (A,B) of calcium silicates can be approximated as follows:

1. 2[3CaO.SiO2] +6H2O 🡪 3CaO. 2SiO2. 3H2O + 3Ca(OH2)
2. 2[2CaO.SiO2] +4H2O 🡪 3CaO.2SiO2. 3H2O + Ca(OH2)

The precipitation reaction (C) of calcium phosphate apatite is as follows:

1. 7Ca(OH2) + 3Ca(H2PO4)2 🡪 Ca10(PO4)6 (OH2) +12 H2O

**Clinical applications of EndoSequence BC Sealer**

For clinical purposes, the advantages of a pre-mixed sealer are obvious. In addition to a significant savings of time and convenience, a pre-mixed sealer ensures a proper consistency and mix. This is important as BC Sealer has been designed as a pre-mixed sealer that sets only when exposed to a moist environment (such as that produced by dentinal tubules). This is a unique development in the world of sealer technology.

The obturation technique associated with this material is straight forward. Simply remove the syringe cap from the EndoSequence BC Sealer syringe and attach the intra canal tip of your choice to the hub of the syringe. Since the particle size of the BC Sealer has been milled to such a fine size, a capillary tip (such as a .014) can be used to place the sealer.

Following this procedure, insert the tip of the syringe into the canal no deeper than the coronal third. Gently and smoothly dispense a small amount of sealer into the root canal by compressing the plunger of the syringe. Slowly backfill your way out of the canal. Using a # 15 hand file or something comparable such as the master cone, lightly coat the canal walls with the existing sealer in the canal. Then coat the master gutta percha cone with a thin layer of sealer and slowly insert it to the working length. The synchronized master gutta percha cone will carry sufficient material to seal the apex. Furthermore, the precise fit of the EndoSequence gutta percha cone in combination with a constant tapered preparation (endodontic synchronicity) creates excellent hydraulics that will allow the sealer to fill the canal space three dimensionally. This ability to drive the sealer three dimensionally as a result of a synchronized fit is what we call “Hydraulic Condensation.”

While BC Sealer has gained great popularity as an endodontic sealer there have still been practitioners who prefer a more thermoplastic approach to obturation. Consequently, Dr. Stephen Buchanan has worked with Brasseler USA to develop a new bioceramic sealer (HiFlow) that has been designed specifically to work with thermoplastic obturation methods. In his own words Steve has stated, “With over 10 years of evidence, I am now convinced that BC Sealer is the best sealer on the market. I have been working with Brasseler to develop a new version of BC Sealer that is optimized for warm obturation. BC Sealer HiFlow will allow clinicians who prefer thermoplastic techniques to fully embrace the biological benefits of BC Sealer.”

**Update on the condensation process**

Initially the bioceramic obturation technique was referred to as a single cone technique. In many cases this is true but the use of the term “single cone” can be misleading. What the bioceramic technique really is, is a “hydraulic condensation” technique. The hydraulic forces are generated as a result of the synchronicity in fit between the EndoSequence rotary preparation and the laser verified master cone. However, more importantly when we talk about hydraulic condensation or a single cone technique let’s think what this really means. The easiest way to comprehend this is to compare hydraulic condensation using a single cone to carrier based methods. Recently, many in the endodontic community have come to the realization that excessive coronal enlargement, particularly of the radicular dentin, can adversely affect the long-term prognosis of the tooth. Real World Endo was among the first to address this concern and we still believe that the key to the long-term success of the endodontically treated tooth is to be conservative with your preparation in the coronal third of the root along with the ferrule effect.

While various obturation techniques in the past have contributed to the problem of over-enlargement of the radicular dentin it was the use of carrier based obturation techniques that truly resulted in wider than ideal orifice enlargement. The rationale behind this “solution” was quite simple and most likely was conceived by marketing and sales people. The rationale was: The larger the hole at the top of the canal, the less likely it would be to strip or denude the carrier of gutta percha or Resilon. Stripping the carrier of gutta percha during insertion historically has been one of the challenges associated with carrier-based obturation.

Certainly, one can get acceptable obturation results with a carrier-based technique when done properly and we further believe there is merit in the concept of filling a root canal with a device that you can “feel.” Think for a moment what we are really doing when we employ the hydraulic condensation method. We are in essence using a stiff carrier (but one that is a stiffer gutta percha not plastic) to deliver a non-shrinking bioceramic sealer into the root canal system. So, while we get the “feel” of a carrier-based technique, we have the advantage of using gutta percha as a carrier to deliver the sealer. After all, it is the sealer that creates the seal in obturation, not heated gutta percha which shrinks significantly when cooled.

**Retreatment of EndoSequence BC Sealer**

Bioceramic sealers are definitely retreatable yet the issue of retreating these cases (and all the associated misinformation) is not unlike that of glass ionomer. Historically there has been confusion about retreating glass ionomer cases and similarly there continues to be confusion about the retreatability of bioceramic sealers. The key is to use the bioceramic sealer as a sealer not a filler. This is why enododontic synchronicity is so important and why the use of constant tapered rotary files makes so much sense (it minimizes the amount of endodontic sealer thereby facilitating retreatment).

The technique is relatively straightforward. An important factor in the retreatment of a bioceramic case is the use of a piezoelectric ultrasonic combined with a copious amount of water. This is especially important at the start of the procedure in the coronal third of the tooth. Work the ultrasonic with lots of water down the canal to approximately one-half its length. At this point add a solvent to the canal (chloroform, xylol or EndoSolv) and switch over to an EndoSequence file (#30 or 35 / .04 taper) and run at an increased rate of speed (1,000 RPM). Proceed with this file all the way to the working length (in straight canals) using solvent when indicated. An alternative with curved canals (and the more popular technique) is to use hand files in the final 2-3 mm and then follow the gutta percha removal with a rotary file to insure synchronicity. Some endodontists also use the XPEndo file (Brasseler USA) for retreatment.

**Bioceramics as a root repair material**

We are all familiar with the success of MTA as a root repair and apico retrofilling material. Furthermore, we know that it is a modified Portland cement and because of such an origin, it has some limitations in terms of handling characteristics. It does not come premixed (and therefore must be mixed by hand), is difficult to use on retrofills, and has such a large particle size that it cannot be extruded through a small syringe. Yet, it has a number of favorable characteristics, including a pH of 12.5which is anti-bacterial. However, the game has also changed in terms of root repairs and apico retrofills. The game changer is the EndoSequence Root Repair material which comes pre-mixed in a syringe just like BC Sealer. This is a tremendous help not just in terms of consistency of mix but also in terms of ease of use. We now have a root repair material with an easy and efficient delivery system.

As a bioceramic cement, the advantages of the root repair material are (again) its high pH, resistance to washout, no shrinkage during setting and its superb physical properties. In fact, it has a compressive strength of 50 – 70 MPa, which is similar to that of current root canal repair materials such as ProRoot MTA (Dentsply). However, a significant upgrade with this material is its particle size that allows the premixed material to be extruded through a syringe rather than by hand mixing and then placement with a hand instrument.

**BC Putty and its use as a pulp capping agent**

A very successful product has been the EndoSequence Root Repair Material Putty. The original putty came premixed in a jar and due to its slightly larger particle size, it set in two hours rather than the traditional four hour set associated with the bioceramic sealer. This was an immediate success but Real World Endo and Brasseler USA worked together to develop a new Fast-Set Putty (available in a syringe) that would set up in just twenty minutes. The technique associated with the Fast-Set Putty is quite easy. Simply remove a small sample from the syringe and create a little cone of the fast-set putty and this will easily stay on a plastic instrument. It makes application of the material very easy to use. The putty can be used for a number of applications including root repairs, perforation repairs, and for pulp capping.

The use of the Fast-Set Putty for pulp capping is marvelous. The technique is actually straight forward. The first challenge with pulp capping is to gain hemostasis. Once hemostasis is achieved, simply place the putty on top of the exposure. The “official” setting time for the putty is twenty minutes but we have found that after just ten minutes the clinician can go back in and place a glass ionomer on top of the putty. The particles in the glass ionomer will bond to the bioceramic particles. Once the glass ionomer is set, simply etch the glass ionomer and restore the entire tooth in your preferred manner. Everything is accomplished in one visit which is ideal especially for young patients.

**Summary**

We believe that bioceramic technology has become the “Gold Standard” of endodontic obturation. BC Sealer can be used in hydraulic condensation cases and in thermoplastic cases, BC Sealer Hi Flow will work well. Furthermore, the development of a Fast-Set Putty has given the bioceramic root repair material even more applications of use. We especially see its use in offices of pediatric dentists. In our opinion, every dental office should have a tube of Fast-Set Putty on hand to address various emergencies.

Endodontics continues to be a dynamic specialty and as we move further ahead, the key is to use the latest technology and material science in combination with long established evidence-based principles.

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