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Innovations in Endodontics Instruments and Techniques

L. Stephen Buchanan, DDS

After a relatively static 30-year period—from the 1950s to the 1980s—endodontic practitioners grew accustomed to a slow rate of change in their field. But that was okay, we were happy to be allowed to save necrotic teeth with endodontic therapy, as opposed to the wholesale extractions that occurred during the preceding 30-year "focal infection" era

In sharp contrast, the last 20 years have seen an accelerating rate of change in the field, to the point where we find ourselves inundated with new techniques and tools on a monthly basis. While separating the gimmicks from the genuine breakthroughs can be daunting and bewildering to clinicians (including specialists), finding technological and procedural advances that actually improve the practice of dentistry makes it worth the effort.

Having been involved in some of the advances described here, I can offer some observations on their use and effectiveness, based on my own clinical experience. Obviously, as a design engineer, I am biased by my involvement in the products I have developed. However, my reputation as a clinical educator has survived my product development career because I have taught the best instruments and techniques to accomplish a given clinical result, regardless of who developed the instrument.

Specifically, I'll describe innovations that address three of the major procedural challenges in conventional endodontics: access, shaping, and obturation.

ACCESS

After 22 years of practicing endodontics, I still find access procedures to be the most challenging part of the process. Every access preparation in a calcified tooth is an opportunity to perforate and destroy that tooth. Every incorrectly performed access preparation makes each subsequent procedure all the more difficult. Fortunately, new tools and procedures have dramatically improved the predictability of successful access outcomes. The biggest advances have come from microscopes, access burs, and ultrasonics.

Microscopes

While microscopes (Figure 1) have been rapidly embraced by the majority of endodontists over the last 12 years, their rate of introduction into general dentists' offices has been considerably slower. The initial appeal of microscopes to endodontists was their potential to enhance surgical outcomes. We found, ironically, that using a microscope reduced the need for surgery in our practices because it significantly improved our conventional endodontic capabilities. Just ask your local endodontist who works with microscopes how he or she would experience re-treatment or surgery cases without a scope, and you'll see a look of horror cross their face.

Without a microscope it is impossible to accurately assess the apical extent of vertical fractures. There is no way to look good in the eyes of a patient when a tooth that has recently had root canal therapy and a crown is then found to be root-fractured and must be extracted. For this assessment loupes are inadequate, as 12X magnification is needed to definitively rule out the presence of root fracture in cracked teeth.

Microscopes also aid access procedures when clinicians are looking for MB2 canals in upper molars or removing posts or broken files. Last, but worst, microscopes are your best friend when you are repairing an access perforation with ProRoot MTA (DENTSPLY Tulsa).

Like our experience in the specialty, general dentists have been bringing microscopes into their operatories to do root canal therapy, and have subsequently found them to be indispensable in their restorative practices. Porcelain veneers require meticulous preparation and cementation, tunneling preparations in interproximal areas are really small, and even simple pit and fissure caries cannot be cut out and restored with the same conservative precision that serious magnification provides.

While loupes are a big improvement over standard vision, their magnification capabilities are primitive compared with the microscope's advantages of a perfect light source and multiple steps of magnification beyond the capabilities of loupes. Add the improved posture of dentists using them, and microscopes are much more than just an aid to access procedures.

Access Burs

The most common mistake made in access procedures is the improper selection of burs. Particularly problematic is the choice of flat-ended fissure burs for initial entry and/or access refinement. These burs will create innumerable ledges in access walls, making it difficult to introduce instruments and materials into canals. Even when the access walls are smoothed out later with a round-ended tapered diamond bur, these nicks and dings will often remain. Therefore, access burs with radiused tips work best.

Another common bur selection error is to choose a cutting instrument that is too large. All access entry paths vary in accuracy as the clinician cuts his or her way to the pulp chamber. If you choose a huge initial entry bur, these small misdirections become grossly over-enlarged access preparations by the time all the dings and irregularities have been removed in the refinement process.

A No. 4 round bur is much too big for initial entry into anteriors and bicuspids, and a No. 6 round bur is also too large for initial entry into molars. When smaller initial entry burs are used, the refinement phase of access preparation will result in totally smooth cavity walls, thereby enabling every procedural sequence thereafter.

With that in mind, let’s review the burs I currently use, and preview a few that have just been introduced to market.
Traditional access burs by function (Figure 2).

(1) Cutting through porcelain: use a No. 4 round diamond bur with water spray.
(2) Cutting through cast metal: use a round-ended cross-cut carbide fissure bur, with water spray if porcelain is present.
(3) Initial entry through dentin or noncast restorations:
•Anteriors and bicuspids—surgical length No. 2 round carbide bur is the right size for these teeth. A No. 4 round bur is much too large for anteriors or bicuspids.
•Molars—a surgical length No. 4 round carbide bur is ideal here. A No. 6 round bur is too large for initial entry into molars, and they also make a sound like a chainsaw when you use them to cut through any kind of metal.
(4) Removal of decay: a surgical length No. 6 round carbide bur is ideal here.
(5) Access refinement: more than half of my access preparations are done with round-ended, surgical-length tapered diamond burs after initial entry has been accomplished with the appropriate round bur. Tapered diamond burs are used to flatten each access wall and smoothly extend the access line angles from each canal orifice out to the cavo-surface of the tooth. They can also be used to cut through pulp chamber calcifications; however, when tapered diamond burs are chucked in a high-speed handpiece, visibility at greater depths quickly becomes inadequate due to the visual obstruction of the handpiece head.

New access burs. The first, new access bur is simply an x-long surgical-length taped diamond bur to solve the forementioned problem. The extra length moves the handpiece head away from the occusual surface for better visibility when burrowing deeply into the calcified teeth.
LA Axxess Burs. The rapid adoption of rotary files by specialists and generalists alike has created an even greater imperative for creating ideal convenience form in access preparations. While clinicians can get away with mediocre access preps when using hand files, they will be quickly and severely punished for the same shortcoming when using handpiece-driven files. Natural or artificially created curvatures in the coronal half of root canals are the most dangerous curvature encountered with rotary instruments.

When an instrument is bent around a curve, the metal it is made of experiences compressive forces on the inside of the curvature, and stretching forces on the outside of the curvature. When spinning in a handpiece, the stretching and compression forces alternate at the frequency of the rpm, causing an accelerated form of cyclic fatigue.

Figure 1. The combination of using a microscope and a doctor's chair with adjustable armrests dramatically reduces the most common occupational disability in dentistry, chronic back and neck pain.

Figure 9. Close-up of BUC tips.

Figure 2. LA Axxess Kit burs. From left to right in order of use: No. 4 round diamond bur, round ended, cross-cut carbide bur, Nos. 2, 4, and 6 surgical-length round carbide burs, surgical-length round-ended tapered diamond bur, extra-long surgical-length round-ended tapered diamond bur, Nos. 1, 2, and 3 latch-grip stainless steel LA Axxess burs, football diamond bur.

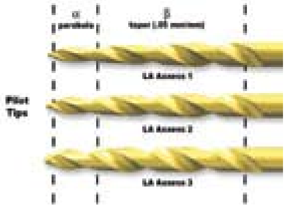

Figure 3. Close-up view of Nos. 1, 2, and 3 LA Axxess burs, showing their three different design geometetries.

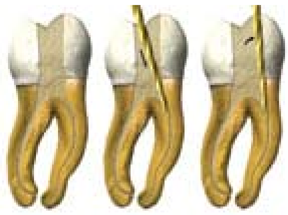

Figure 4. A No. 1 LA Axxess bur being used to create the straight-line file path that is so essential in preventing rotary file breakage. The bur, rotating at 5 to 20k rpm is simply pushed into the canal orifice and then tipped up to the ideal line angle extension.

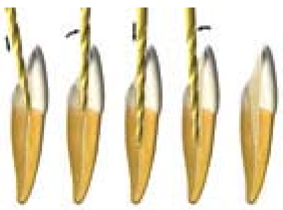

Figure 5. A No. 3 LA Axxess bur being used to cut a straight-line file path in the access cavity of an anterior tooth, effortlessly removing the dangerous dentin triangle below the cingulum.

Figure 10. Spartan's ultrasonic tip stand with a groove in the front that holds a tip wrench.

Figure 11. A BUC-2 ultrasonic tip is being used to "sand" the pulp chamber floor smooth after pulp stone removal.

Figure 12. DENTSPLY Tulsa's GT System components (from top to bottom): hand file, rotary file, gutta-percha cone, paper point, and obturator.

Figure 13. GT Obturators in each of the GT File sizes.

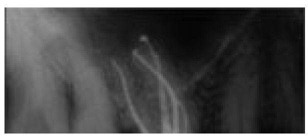

Figure 6. LA Axxess Kit with bur stand.

Figure 7. A BUC-1 ultrasonic tip being used to break a large attached pulp stone off the pulp chamber floor.

Figure 8. Nos. 1, 2, and 3 ultrasonic BUC tips from Spartan Corp.

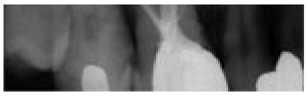

Figure 14. A beautiful endodontic result in a case with long, narrow, curved canals; one of the indications for GT Obturators. Note the narrow coronal shapes, the excellent apical accuracy, and the three-dimensional fill achieved with carrier-based obturation (Courtesy of Giuseppi Cantatore).

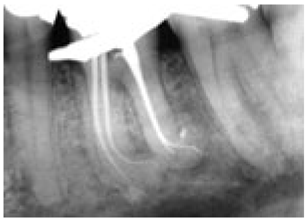

Figure 15. Lower molar with severe multi-planar root canal curvatures. The distal canal was filled with a GT Obturator due to the presence of a serious apical impediment that prevented a gutta-percha cone from being fit to length. Note the impressive apical accuracy and three dimensionality of the fill. Cones were fit in the mesial canals in preparation for a System B fill.

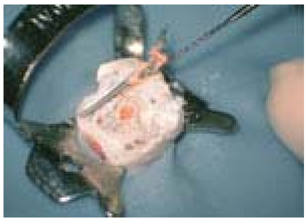

Figure 16. GT Obturator after removal with a BUC-1 ultrasonic tip, a No. 15 Hedstrom file and a curved hemostat. Total time for removal after access completion: 30 seconds.

These forces are most destructive in the large diameter regions of rotary instruments because of the greater disparity between the compressive and stretching forces. Therefore, the more cervically positioned the curvature, the more challenging it is to avoid breaking an instrument in that canal path. For these reasons, adequate extension of access line angles is critical to creating a straight-line entry path into canals. Clinicians must be especially careful to create straight-line file paths in anterior access preparations, and in the MB line-angle extension of access preps in lower molars.

LA Axxess burs (Figure 3) (newly introduced by SybronEndo) were designed to solve this serious problem. They have a completely radiused pilot tip that extends beyond the cutting flutes to eliminate ledging at orifice levels and dangerous overextension into curved root canals. In the alpha flute region behind the noncutting pilot tip are 3 mm of very sharp cutting flutes that cut an ideal funnel shape that guides files, without impediment, into the canal beyond the bur's apical extent of cutting. This parabolic flute region transitions into the beta flute region that consists of 9 mm of cutting flutes with a 0.05 mm/mm taper. They were designed to have a full 12-mm length of flutes so they can cut the full height of the access cavity.

In the SybronEndo Axxess Bur kit, two types of LA Axxess burs are available: a high-speed diamond-coated bur and a fluted stainless steel latch-grip design in three sizes.

The high-speed diamond version of the LA Axxess concept comes in a single size, and is used after the tapered diamond bur to effortlessly tip the access line angles exactly upward from each canal orifice to the cavo-surface of the access cavity.

The LA Axxess burs with a latch-grip design are intended for use in a standard slow-speed handpiece at 5,000 to 20,000 rpm. They have two non-landed stainless steel flutes for aggressive side-cutting in dentin. Beyond the cutting surfaces, they have the same basic features as the diamond version, including radiused pilot tips, parabolic cutting blades, a 0.05 shank taper, and 12 mm of cutting flute length.

The stainless steel used for these burs is somewhat counter to the recent trend of increasing use of nickel-titanium (NiTi) for endodontic cutting tools. This was decided for two reasons: stainless steel is easier to grind to a sharp flute edge and, in this application where we need to cut a straighter path to or into the canal, the stiffness of stainless steel is a definite advantage over the flexibility of nickel titanium. These LA Axxess burs come in three sizes, varying primarily by their tip diameters: the Nos. 1, 2, and 3 have pilot tip diameters of 0.2 mm, 0.35 mm, and 0.45 mm, respectively. These burs are used in small, medium, and large roots, respectively. Use of these instruments is similar to the diamond LA Axxess Bur. They are pushed smoothly into the canal orifice and tipped up, while spinning, to the access line angle, resulting in an ideal line angle extension (Figure 4). Unlike the diamond version, these burs can also be used in the canal itself. This helps to further eliminate any irregularities between the access line angle and the canal orifice, so all subsequent instruments and materials can be placed effortlessly in the canals.

A serendipitous finding in testing prototypes of the fluted LA Axxess burs was how rapidly they could open up canals with no cervical curvatures. At 5,000 to 20,000 rpm, these instruments can cut most of the shape needed in the coronal half of a root canal preparation in less than 5 seconds, greatly reducing the fatigue on the NiTi shaping files to follow (Figure 5). SybronEndo has introduced these burs in a kit form that includes a sterilization stand (Figure 6).

Ultrasonics

Since its introduction into endodontics for surgical applications by Dr. Gary Carr in San Diego, ultrasonics has become increasingly useful in other re-treatment applications as well—notably for the removal of separated instruments in root canals. In conventional access procedures ultrasonic tips are indispensable for access refinement, locating MB2 canals in upper molars, finding calcified canals in any tooth, and the removal of attached pulp stones (Figure 7).

Access refinement. The visual access and the perfect control that ultrasonic cutting tips provide during access procedures makes them a must-have tool for dentists who treat molars. Molar access is hard for all clinicians, and I have been especially grateful for the improved experience and access results that ultrasonics have made possible in these difficult teeth. With line-angle extension burs and these ultrasonic tips clinicians can cut access cavities in any tooth in much less time with consistently ideal access outcomes.

New ultrasonic access tips (Figures 8 through 10). A new set of tips I designed for Spartan Corp (BUC-1, -2, and -3) for conventional access procedures makes it easier to find MB2 canals, smooth pulp chamber floors after cutting out attached denticles, and remove posts.

Looking for MB2 canals in upper molars. Previous ultrasonic tips designed for this purpose have pointy tips which cut grooves in the pulp chamber floor, mimicking the fin coming off the MB1 canal, which experienced clinicians know to follow to the MB2 orifice, indicating an erroneous position for the MB2 orifice.

The BUC-1 ultrasonic tip is basically a round-ended tapered diamond bur shape, so when it is used to cut a trough between the MB1 and palatal orifices, the resulting smooth surface at the base of the trough readily discloses the MB fin and the MB2 orifice when intersected. The round trough shape discloses MB canal fins as a white line and the MB2 orifice as a distinct white dot at the palatal extent of that line (often on the mesial access wall, not on the pulp chamber floor).

Removing attached denticles, smoothing pulp chamber floors, and getting into calcified canals. The BUC-1 is also useful for cutting around attached denticles. The vibration of this ultrasonic tip will often dislodge these pulp stones off the pulp chamber floor. However, more stubborn pulp stones will need to be removed by cutting around them, crosscutting them, and levering them out with a spoon excavator, leaving a highly irregular pulp chamber floor. Pulp chamber floor anatomy can be very helpful in locating canals, but to see the floor coloration a flat plane is needed. The BUC-2 tip is designed with a flat disc shape to safely plane the pulp chamber floors after attached denticles have been cut out (Figure 11).

Finally, the BUC-3 (Digger) has an extremely active tip for cutting apically into calcified canals and for troughing around posts. The BUC-2 tip used on high power is then very effective for banging posts out after troughing has been completed.
A final comment on ultrasonics: Clinicians who are trying ultrasonics for the first time should be advised that a light touch with these tips is needed. Handpiece burs cut faster if you push them harder against the tooth. Because ultrasonic tips cut by moving against the tooth surface in a very small amplitude of movement, pushing them firmly against the tooth not only dampens their action but also dramatically reduces their life span.

SHAPING
The last 10 years have seen virtually every part of our shaping procedures changed with the introduction of NiTi to endodontics. The incredible strength and flexibility of this exotic alloy have allowed the manufacture and use of instruments that would have been impossible in stainless steel. Testament to the importance of this metal is the increasing number of shaping instruments available, some with consistent tapers, some with variable tapers, and a wide range of geometries in between.

Old Files, New Emphasis

Regardless of the shapes of the NiTi files used, the issue of greatest concern is their safe use in a handpiece. Clinicians who have trained up to use them correctly have found that their ease of use and remarkable efficiency have actually made it too expensive not to use them. Dental schools have seen their productivity double, and specialists have seen the same. The only concern expressed by dentists using these instruments is the fear of separation when the handpiece-driven file is overstressed. As described in previous articles in Dentistry Today (February, October, November, and December 1999, and January and February 2000), frequent replacement with new instruments is critical, as is the incorporation of a crown-down procedure to cut the shape so as to avoid overstressing the smallest, most fragile instruments.

However, there are many cases of severe and often hidden curvatures that can cause brand-new instruments to separate, even when used with correct technique. The introduction of torque-limitation electronic handpieces has significantly decreased the incidence of breakage, however tortuous root canals can still pose a threat.

The simplest and most predictable solution to difficulty in getting a shaping file to length in one of these canals is to finish the shape with a hand GT File. The GT System is the only set of rotary files on the market with matching hand files, ironically, because this design was first realized in hand file form (Figure 12). When the rotary version was introduced 3 years ago the hand files were de-emphasized in importance because of the rotary files' much greater ease of use.

Recently, however, they have regained some of their importance in the GT technique based on experiences gained at the UMKC Dental School.1 Concern about students breaking instruments inspired the faculty to limit the use of rotary files to 2 mm from full length, with the shape being finished using a GT hand file. The shocking result of that technique design was that in the entire first year of using the GT system in this manner, students broke only two GT files.

So the next time your rotary files are struggling to cut to length around nasty canal curves, pull out a hand GT File. Due to their sharp triangular blades and the rapid cutting action that occurs with the reversed Balanced Force Technique with which they are used, hand GT Files will usually cut the last 2 mm through a tight or bent canal in only three to five cutting strokes.

OBTURATION
Twenty years ago, my biggest educational challenge in teaching dentists state-of-the-art filling techniques was to convince them to spend an hour to use Schilder's vertical condensation of warm gutta-percha technique, when they only spent 15 minutes filling the same molar with lateral condensation. Today, my job is easier, as I can simply ask: Why do you want to spend more time to do lateral condensation, which isn't predictably three dimensional, when it takes less time to do a centered condensation technique, which is extremely effective in filling fins, loops, isthmuses, and lateral and accessory canals?

The two best-known forms of centered condensation have been around for more than a decade: a technique instrument set that I developed, the Continuous Wave of Condensation Technique with the System-B Heat Source (SybronEndo) and temperature-controlled electric heat pluggers; and carrier-based obturation, developed by Dr. Ben Johnson and first introduced as Thermafil (DENTSPLY Tulsa).

Both of these filling techniques work the same, but inverse to the three-part impression systems used in restorative dentistry. These impression systems consist of a hard tray which pushes a heavy-bodied impression material against the teeth, which pushes a thin-bodied impression material into the smallest detail. With Centered Condensation Techniques, the electric heat pluggers and the plastic carriers are like the tray, the gutta-percha is the heavy-bodied material, and sealer performs the similar function of the thin-bodied impression material. In both of these techniques the sealer not only affects the seal in the canal, but also acts like a lubricant, helping the warm gutta-percha to slip and slide through tortuous canal spaces.

Testament to their ease of use and their amazing ability to fill root canal complexities with sealer and gutta-percha in seconds, these two centered condensation techniques are the fastest growing obturation methods around the world. I have written many articles in Dentistry Today on the Continuous Wave Technique, and while there is design work currently being done on a new generation of System B pluggers, the most recent innovation in centered condensation was the introduction last year by DENTSPLY Tulsa of GT Obturators (Figure 13).

GT Obturators

GT Obturators are very similar in most respects to Thermafil, but differ in the fact that these carriers have been designed to ideally work in each of the specific shapes created by GT files. One of the benefits of the predictable shapes created by GT files is that carriers can then be optimized to match those shapes so that there is enough of a gap between the carrier and the canal wall to allow all of the surplus material to escape coronally, but not so large a gap as to allow a void in the filling. As I have gained experience with these obturators, I have found that the technique they are used with will seriously influence apical accuracy above and beyond the contribution provided by the precise carrier geometry.

When using carrier-based obturation, unlike conefit techniques, surplus sealer is to be carefully avoided. If a pool of sealer is left in the canal after introduction with a paper point, it will be expelled through the terminus of the canal when the carrier, which is surrounded by gutta-percha, captures the surplus sealer just below the orifice and acts like a squeegee, driving it through the end of the canal. The procedural solution to this problem is very simple: after placement of liberal amounts of sealer in the canal, use successive paper points to blot the surplus sealer until one of them is seen to be spotted instead of coated with sealer near its tip.

Two more important technique tips that will help improve the apical accuracy of carrier-based obturation is to trim the gutta-percha off the end of the carrier to expose 1.5 mm of the tip, and to measure and place the carrier 1 mm short of full length. When placing an untrimmed carrier in a canal, surplus gutta-percha is often extruded unnecessarily, even when the carrier is held short of full length. As the gutta-percha moves through narrowing diameters of the root canal, much is displaced coronally, but some of it also squeezes ahead of the carrier. There is usually a gutta-percha and sealer “front” moving 1 mm ahead of the tip of the carrier; therefore, if the carrier is taken to full length this excess sealer and gutta-percha will be expelled. If the gutta-percha is removed from the end of the carrier, if surplus sealer is blotted, and if the carrier is held 1 mm short of full length, remarkable apical accuracy will be achieved.

As I have gained more experience with carrier-based obturation, I have found an increasing number of cases where this would be the filling technique of choice. As Giuseppi Cantatore,2 a talented endodontist from Rome, Italy, states, carriers are ideal for long, narrow, severely curved canals, as the obturator can be taken just short of the last 1 mm of the canal, where a plugger in that type of canal would fit no closer than 7 or 8 mm from length with arguably less well-condensed gutta-percha in the apical region (Figure 14). Another indication for carrier-based obturation is when filling a canal with an impediment around which a cone cannot be fit. Because of the gutta-percha and sealer “front” ahead of the carrier, the canal beyond the impediment can be ideally filled in spite of the carrier stopping at the point of the impediment (Figure 15).