Endodontic success: It's all about the apical third

By E. Steve Senia, DDS, MS, BS

It goes without saying that as professionals we should strive for the highest success possible. Yet, defining and determining long-term success isn't always black and white. For example, is a tooth that hurts while chewing really a success? Some say yes — it's still in the mouth. I have a problem with that kind of thinking. Successful cases should be fully functional and pain free. Similarly, how much time should elapse until you can consider a root canal treatment successful? Three years is a common figure. Inadequate and even very poorly done root canal procedures often last at least that long — or even longer — thanks to an efficient immune system.

I believe that most true endodontic failures are caused by inadequate apical cleaning — period. In dental school we were taught that cleaning and sealing root canals, especially in the apical third, is the most critical part of the procedure. This basic concept has not changed, nor has the fact that instrumenting the apical third is usually the most difficult part of the procedure. In my many years of teaching and lecturing, I don't recall any serious challenges to these widely accepted beliefs. Given that almost all dentists agree, why do so many still use instruments and techniques that do not address these vital issues? Why have we been slow in converting to better instruments and techniques? The answer is inertia. It is much easier to keep doing the same thing over and over than it is to change. But is this the way of a caring professional?

About 20 years ago, Bill Wildey and I questioned the antiquated design of K-type instruments. We learned that existing metal and machining technologies were the limiting factors. You can dream about an ideal instrument, but you can have only what can actually be made. Even today, machining technology and materials are still limiting factors, but they have advanced tremendously. While nickel-titanium is better than stainless steel in most respects, manufacturers simply changed the material but retained the basic tapered design. That's only going halfway.

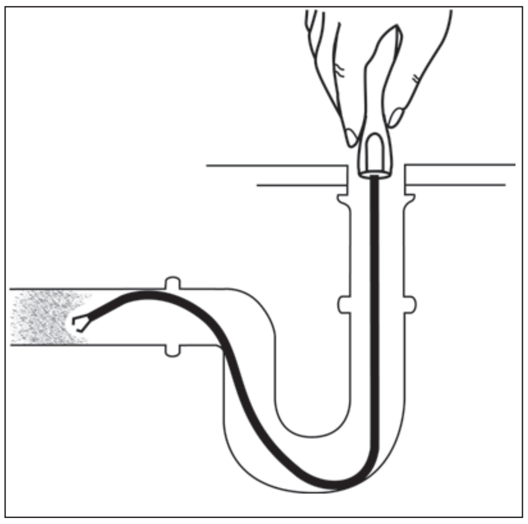

Fig. 1: A plumber's snake in an endodontic article? Business management consultants call it "Best Practices" — looking at how others solved a similar problem and applying their principles to your application.

By cross-sectioning and microscopically examining a very large number of endodontically treated teeth, it became painfully obvious to Bill and me that many times root canal treatment did not adequately clean the apical third of canals. Better instruments and techniques were clearly needed. We made prototypes of our design by grinding K-files to form an instrument with a short blade on the end of a long, smooth flexible shaft. Why such a design? We theorized that cleaning the very end of a long "pipe" (canal) required an instrument similar to a plumber's Roto-Rooter (a short cutter at the end of a long flexible shaft) *(Fig. 1)*. In 1992, we reported our thoughts and findings in an article titled "Another Look at Root Canal Instrumentation."[1]

Canal anatomy

Computer tomography has made visualizing canal systems a much simpler task. We've learned that nearly every canal is curved. What may appear as a straight canal in a two-dimensional X-ray almost always has some degree of curvature in an unseen plane. Furthermore, the cross-sectional shape of most canals is not round but oval (mimicking the oval shape of most roots). Lastly, few canals have a constant taper; instead, they exhibit nearly parallel walls in multiple segments throughout the length of the canal.

Here are some generalizations about canal anatomy worth remembering:

- Most canals are curved in one or more directions. The more severe a curve, the more difficult the treatment.
- Most canals are oval in cross-section. Oval canals have *two* diameters, a minor (smaller) and a major (larger) diameter. The quality of cleaning is dependant on instrumenting to the larger diameter; it's Working Width *(Fig. 2a)*. Working Width (WW) is best understood by studying cross-sections of apical canals. If the greater diameter of the original canal is measured, the correct WW is an instrument size slightly larger than that dimension.
- The apical constriction is the narrowest point of the canal with an average diameter of just under 0.30 mm. However — and this is important — just coronal to the apical constriction canal diameters increase significantly, ranging from 0.35 to 1.00 mm and higher.[2-4]

The importance of tactile feel

Since we cannot see deep into curved canals, we rely on an instrument's tactile feedback to give us clues about canal anatomy. Canal statistics are handy, but because canals differ widely we are working blind without feedback. Let's stop thinking canals are basically the same size and shape, because they are not. The solution is to stop guessing and begin using instruments that provide accurate feedback. We should customize every one of our canal preparations. As Spångberg so aptly stated, treating canals similarly is like forcing everyone to wear the same size shoe — one size doesn't fit all![5]

Change begins by questioning current thinking and creating new paradigms

- Since canals are mostly curved, shouldn't instruments be as flexible as possible? Shouldn't they warn us when encountering a curve so severe that they are likely to break? Since instrument separation is of great concern, shouldn't manufacturers make them safer? We didn't stop driving cars; rather, we installed seat belts, anti-lock brakes and airbags for added safety. Addressing breakage by using instruments just once is an expensive solution and one that doesn't always work, either.

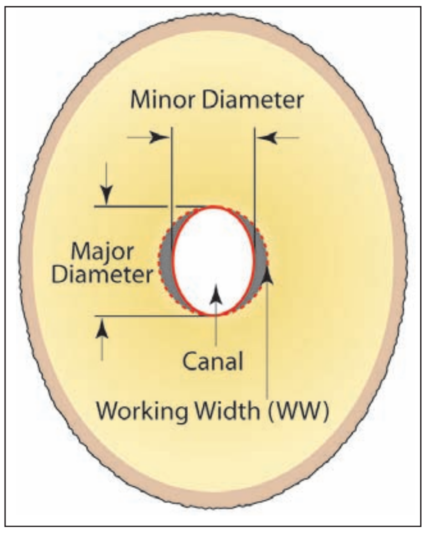

Fig. 2a: Admittedly, a pure oval canal is somewhat simplistic, but it helps make the point. Working Width (WW) is best understood by studying cross-sections of apical canals. If the greater diameter of the original canal is measured, the correct WW is an instrument size slightly larger than that dimension.

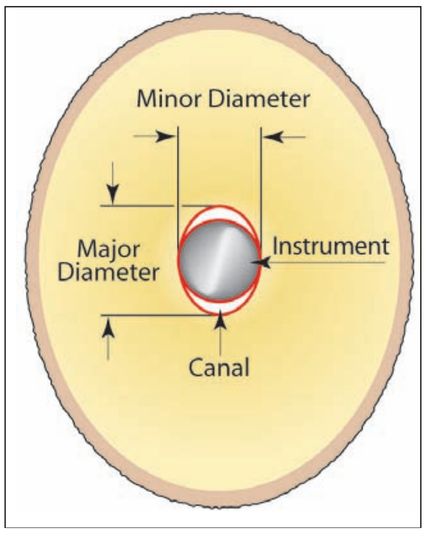

Fig. 2b: An instrument that cuts just at the minor diameter leaves a lot of wall untouched.

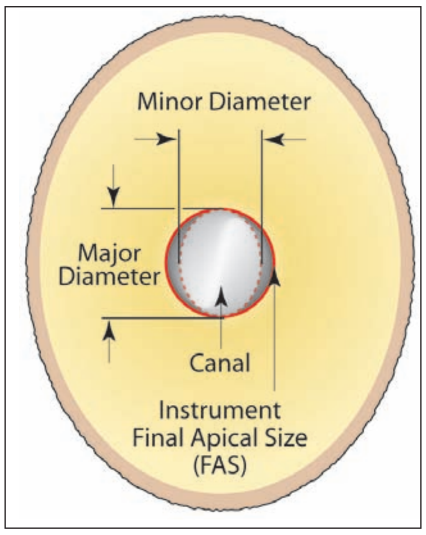

Fig. 2c: Some instruments may tell you when you are cutting with the minor diameter size, but of greater value is when they advise you when cutting with the major diameter instrument size.

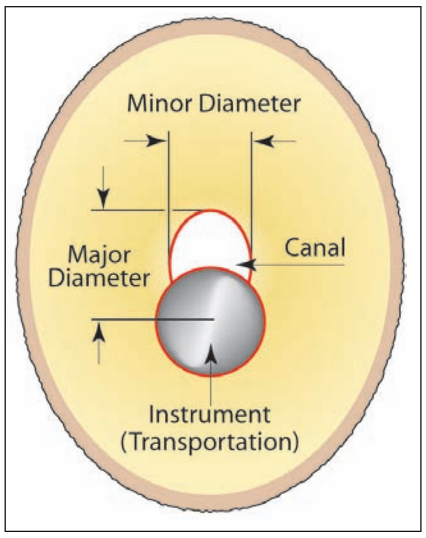

Fig. 2d: Instruments must be the right size and be flexible enough to stay centered in the canal. A correct instrument size can do more harm than good if it isn't flexible and canal transportation occurs.

• Since canals are oval *(Fig. 2a)*, shouldn't an instrument tell us when it's not cutting canal walls in the apical third, when it is doing some cutting at the minor diameter *(Fig. 2b)*, and when it is cutting all canal walls because it has reached the size of the major diameter *(Fig. 2c)*? By experiencing these transitions, we would know when apical instrumentation is complete. Clearly, if we stopped instrumentation at the minor diameter size the two elongated ends of the canal would remain uninstrumented and full of debris. Yet, just instrumenting to the correct diameter isn't enough. A rigid instrument that transports away from the canal's center can do more harm than good *(Fig. 2d)*.

• Most canals do not have a constant taper. In many cases canal walls are parallel in some segments of the canal. This shape doesn't always lend itself to being instrumented to a tapered form. So, why should our instruments be tapered and why must we insist on preparing a tapered shape when we know this doesn't match the natural anatomy? Instead, canal instrumentation should closely mimic the original anatomy, from orifice to working length.

• Canals vary widely in apical diameters *(Figs. 3a, 3b)*, usually 0.35 to 1.00 mm or larger. Instruments should tell us when the canal is properly prepared. If they can't, exactly how are we supposed to determine this? Furthermore, shouldn't a wide range of instrument sizes be made available to match the wide range of canal sizes? Isn't it rather astonishing that some manufacturers actually brag about an instrument system containing "just a few instruments"? Isn't this a marketing ploy that flies in the face of overwhelming clinical and scientific evidence that canal sizes vary immensely? Isn't it time to challenge techniques promoting "just a few instruments"? Must we be in such a rush that we compromise anatomical structure and clinical outcomes?

Application of new paradigms

The new LightSpeed LSX™ instrument and EndoVac® irrigation system are the cornerstones of the new paradigm we call Smart Endodontics™. We'll discus how EndoVac is creating new irrigation paradigms in a future article. For now, we'll look at how LSX *(Fig. 4)* is shifting our thinking away from current instrumentation paradigms.

Flexibility

When compared to tapered instruments, the LSX is by far the most flexible. Given the same tip size, no other instrument design even comes close. Flexibility allows instrumenting to naturally occurring large apical diameters. No longer must we compromise canal cleanliness by ending our preparations at small instrument sizes to avoid transportation and ledging. Instrumenting to the correct apical size (avoiding both under and over instrumentation) is just half the battle. The "right size" instrument must stay within the limits of the canal or the resulting transportation can do more harm than good.

Maxillary Apical Sizes (Working Widths)

	Compendium 1991	LightSpeed 1997	OOO 2000	J Endodon 1977
Central & Lateral	80	60 – 70	50 – 60	60 – 90
Canine	80	60	60	50 – 70
Premolar	45 – 80	50 – 60	40 – 65	35 – 90
Molar MB	45	45	35 – 50	35 – 60
DB	45	40	35	40 – 60
P	60	50	40	80 – 100
JOE 10/99	MB: 40 – 55	DB: 40 – 55	P: 55 – 80	

Mandibular Apical Sizes (Working Widths)

	Compendium 1991	LightSpeed 1997	OOO 2000	J Endodon 1977
Incisors	60	60	55	45 – 70
Canine	80	55	45	50 – 70
Premolar	45 – 80	55	40	50 – 70
Molar MB	45	40 – 45	45	35 – 45
ML	45	40 – 45	45	35 – 45
D	60	50	50	60 – 80

Figs. 3a, 3b: Tables show canal preparation sizes in the apical third (range of working widths). Notice the minimum size is 0.35mm (#35 instrument at the tip). However, most widths are much larger. The goal of instrumentation is to use the correct Final Apical Size appropriate for each canal and flexible enough to stay centered in the canal. As I said before, more rigid instruments cause more harm than good.

Fig. 4: The LSX has a short cutting blade, a non-cutting tip and a highly flexible and smooth shaft. This design makes it ideal for preparing the apical third of the canal — the most important and most difficult part to prepare properly. It also has a safety release feature that greatly reduces the chance of leaving a broken fragment in the canal.

Fig. 5: SimpliFill obturators are made to match a canal prepared by LSX. They make obturation predictable, fast, easy and provide an excellent seal.

Safety

Curves break instruments. Most tapered instruments will go around abrupt curves only to break without warning. The LSX warns you when encountering such curves (by not advancing unless it's pushed much too hard). The good news is that LSX is designed with a safety release feature that greatly reduces the chance of an irretrievable separation. When an LSX is overstressed and a safety release event occurs, the shaft breaks loose from the handle or twists-up on itself *(Fig. 4)*. The instrument can no longer be used, but it can be retrieved. In the unlikely event that a break occurs elsewhere, the short, spade blade offers a good chance of bypassing the segment.

Preliminary results of an ongoing study at Creighton University involving undergraduate dental students shows an irretrievable separation rate between 0.3 – 0.5%. This rate is far lower than the 3 to 8% (and higher) separation rates involving tapered instruments.[6,7]

Tactile feedback

The smallest LSX blade is an ISO #20, which is smaller than most canals. Being smaller, the blade just glides gently against the wall. If it's touching the wall why doesn't the rotating blade cut? Because the very flexible shaft doesn't push the blade against the wall with sufficient force to overcome the hardness of dentin. When the blade is large enough to simultaneously contact two walls of the canal it begins to cut. Where? Where the distance between the two walls is the shortest — at the minor diameter *(Fig. 2b)*. When cutting at the minor diameter instrument feedback reveals it isn't working very hard because it is not — it's cutting only a small section of canal wall. As we progress to larger and larger LSX instruments we can feel the blade working harder and harder cutting more dentin until the major diameter is reached *(Fig. 2c)*. At this point the canal is round and instrumentation is finished. To instrument to larger sizes beyond this point is not desirable. The instrument size that achieves this roundness is called the Final Apical Size (FAS). Since instrumentation can't always be perfect due to complex apical anatomy, I recommend a thorough irrigation with EndoVac, which uses true apical negative pressure, to help ensure a clean canal.

Tapered instruments are unable to provide accurate tactile feedback, particularly in the apical third where it is most needed, because their long blade is always cutting somewhere. The presence of dentin filings at the tip of the blade does not mean (as some believe) that the blade is touching all canal walls. The tip flutes of an instrument can fill with dentin even though it is cutting only one side of the canal wall because it is rotating — leaving the other canal walls untouched *(Fig. 2d)*.

I'm not saying that tapered instruments should not be used. Small tapered K-files serve us well to create a glide path to working length. Tapered rotary instruments are useful for cleaning and creating a funnel shape in the coronal third. This helps improve the glide path to mid-root. However, use caution in the mid-root area or risk dangerous thinning of the dentin, or even a strip perforation in furcation areas. The term "deep shaping" using larger, more rigid instruments makes me cringe. Don't do it — especially in mid-root curves! Respect and conserve the natural anatomy.

I know that some readers must be wondering how to obturate a canal without an ideal tapered shape? We've developed an obturation system called SimpliFill® *(Fig. 5)*. Its design frees us from having to create an artificial tapered shape just to obturate with tapered cones or to use condensing devices deep in the canal. SimpliFill's ability to seal the canal is as good, if not better, than other techniques. It requires much less time, skill, equipment and patience.

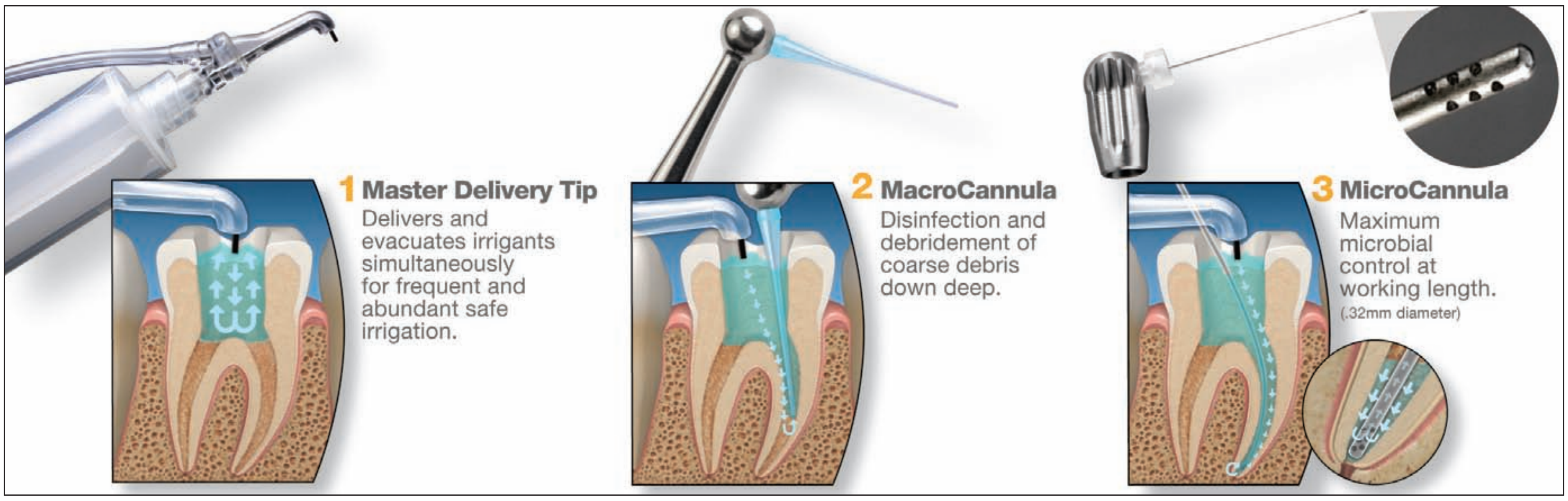

Fig. 6: EndoVac is a unique, patented system of true negative apical pressure. EndoVac circulates irrigant from the chamber down into the apical canal by way of a small gauge needle attached to the Hi-Vac line. This assures safe and thorough irrigation of the apical third.

Fig. 7: The cordless HotShot backfill gun makes for an easy and effective obturation behind the SimpliFill Plug.

Instrumenting to the proper diameter

Working Width — if you are not familiar with this term, don't be surprised. It's relatively new. Working Width relates to canal diameter coronal to the apical constriction. It was first used by Dr. Jou from the University of Pennsylvania.[8] I like this term very much, because it is a valuable reminder that canals are three-dimensional. This means that all instrumentation techniques have to contend with both a working length and a working width. Incidentally, this area of the canal (coronal to the apical constriction) was called, and with good reason, the "Forgotten Dimension" by Carl Hawrish, an endodontist from Canada (deceased).[9]

Your goal should be to avoid both under and over preparing the canal. Achieving this doesn't have to be a mystery anymore. Anatomical research tells us that canals come in many different diameters, from small to very large. Therefore, we make LSX in many sizes too, #20 to #160 — with the most common Final Apical Sizes ranging from 45 to 80.

The proof is in the cross-section

As part of our hands-on courses, participants instrument and obturate extracted teeth with LSX and SimpliFill and actually see the results. It's one of the highlights of the course. Teeth are cross-sectioned, photographed under a microscope and projected onto a big screen for group discussion and evaluation. Don't worry, we don't give grades — it's a learning process. Participants are amazed at how well they do with the technique; more than 90% get the Final Apical Size correct the very first time. With practice it becomes second nature. View sample cross-sections at www.discusdental.com/endo. While you are at the Web site, look for case reports, course schedules, technique guides and more than 100 references supporting what I've discussed above.

The LSX Technique

This short article doesn't allow us to get into much detail, so here is an overview:

1. Make a straight-line access and flare the coronal third of the canal.
2. Establish a glide path to working length (WL) with #20 K-file.
3. Start NiTi rotary preparation with the LSX # 20 to WL. Continue with increasing instrument sizes until tactile feedback indicates the Final Apical Size (FAS) has been reached.
4. Subtract 4 mm from WL and instrument to this length with the next larger LSX size. This completes the preparation of the apical third (5 mm).
5. Prepare the middle third with the next 2 or 3 larger LSX sizes.
6. Irrigate with EndoVac using your irrigants of choice *(Fig. 6)*.
7. Obturate the apical 5mm with a 5mm SimpliFill GP or Resilon® Plug that is placed with a removable carrier. Complete the obturation of the middle and coronal thirds with the HotShot™ cordless backfill gun *(Fig. 7)*, or technique of your choice.

Now - What to do with this information?

Try to overcome inertia knowing full well it may be somewhat difficult; most of us just don't like change. It is our hope that the existing scientific evidence will convince you to overcome inertia, get rid of the old, bring in the new, and embrace the future — now, not later. Transition to this new technique slowly, start with easy cases and gradually work up to more difficult cases as your confidence and abilities increase. Remember you didn't learn your current technique in a day either.

If you are ready for change, please call Discus Dental at (800) 817-3636. They will send you a free CD showing what Smart Endodontics is all about.

I wish to thank Steven S. Senia, BSIE, MBA, for his valuable contributions to this article.

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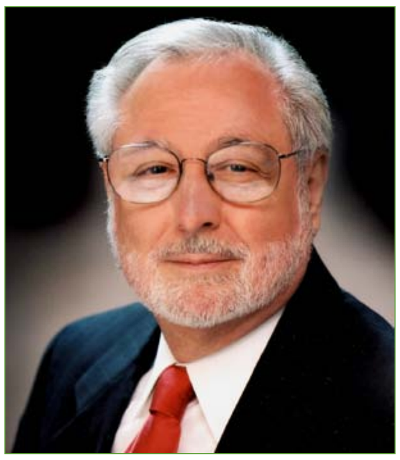
About the author



Dr. E. Steve Senia earned a DDS degree from Marquette University in 1963. He re-entered the Air Force (previously served as a pilot) and completed a GPR Residency. In 1969, he received a MS and Certificate in Endodontics from The Ohio State University. He served in the Air Force and retired in 1981 as a Colonel and Chairman of Endodontics at Lackland AFB, TX. He then became Professor and Director of the Endodontic Postdoctoral Program at the University of Texas Dental School at San Antonio. He retired in 1992. Dr. Senia is a Diplomate of the American Board of Endodontics. He is a former member of the Editorial Board and the Scientific Advisory Panel of the Journal of Endodontics, an Editorial Advisor for the journal of Endodontic Practice and a consultant for the NASA Space Program. He has lectured and published extensively and is the co-inventor of the LightSpeed root canal instrumentation and SimpliFill obturation systems.

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