CLINICAL ARTICLE

Part 1: "I would Rather have a Root Canal than..."

Francis W Allen discusses the challenges of cleaning the canal thoroughly to minimize pain and ensure long-term success

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Abstract

Cleaning and shaping of root canal system forms the most important step in root canal root canal therapy. Unfortunately most of the instruments and techniques advocated are unable to remove residual debris and bacteria, ultimately resulting in pain and failure. To eliminate the causes of pain, and ensure success, we must use instruments and employ a technique that can best accomplish proper cleaning and shaping. Virtually all canals have parallel walls, and are curved and oval in shape. Hence tapered instruments are unable to clean the canal effectively and increase the chances of ledges and transportation and extrusion of debris beyond the apex. With the introduction of Light Speed technology primary goal of endodontics which includes removal of debris safely and effectively can be achieved. This article focuses on the use of Light Speed technology to overcome the difficulties posed by the other instrumentation and techniques to achieve debris and bacteria free canal system.

Keywords: Light speed, debris, tapered instruments, canal transportation, apical gauging.

Why has this phrase—"I would rather have a root canal than…"—become a standard for something to avoid? Dr. Gordon Christensen once asked an audience of dentists about their personal experience of receiving root canal therapy (RCT). Roughly 50% of those dentists indicated that they still felt some lingering discomfort from an endodontically involved tooth, presumably treated by colleagues they knew and trusted.[1]

Isn't it likely that this would be true for many of our patients as well? Does the general practitioner (GP) throw in the towel and let RCT stand for "refer canal treatment" or do GPs and endodontists accept Dr. Christensen's suggested paradigm shift to implants?

What is it about RCT and Pain?

Our body's healing process involves inflammation; inflammation creates pressure, which in turn creates pain. Our job is to eliminate the cause of inflammation—by eliminating as much of the debris within the root canal system and the bacteria hiding within it.

Unfortunately most of the instruments we have to work with are inadequate for the job. Radiographs can't tell you when the canal is clean. We all have seen great RCT radiographs with immediate and chronic pain. Christensen's 50% response may seem far fetched, but what would Wu's research in 2009 say about it?[2] Wu reports that the most recent success rate studies range from 71 to 83%. After reviewing 120 articles, Wu found that cases considered successful by radiographic observation in eliminating apical periodontitis were actually unsuccessful when analyzed by cone beam computed tomography (CBCT) from 30 to 75% of the time. Wu concluded that published success rates would have been even lower had recall rates been higher and retreatments and extractions been included. When you do the math, Christiansen's 50% success rate may be too high!

We simply have to do better. Residual debris and bacteria left in the canal are just waiting to cause apical periodontitis—pain and failures down the road. One example I find particularly interesting are those cases where

Fig. 1A: Christensen states that in about half of RCT performed on dentists, they continue to have chronic awareness or pain

Fig. 1B: Why does a great looking RCT still hurt when pressed from the side?

a tooth is basically asymptomatic yet hurts when the patient presses on the side of the tooth (Figs 1A and B). Why is that? Gutierrez showed that nearly 100% of all canals end short of the apex, their foramen exiting out the side of the tooth.[3] Therefore, it stands to reason that when the patient presses on the side of a tooth, they rotate around the fulcrum of the root, creating pressure on the inflamed periapical tissue. Ouch!

Pain and failure do not translate into good practice management. To eliminate the causes of pain, and ensure success down the road, we must use instruments and employ a technique that can tell us when we have cleaned the canal.

Fig. 2: Obviously the gauging file doesn't bind until reaching working length. This theory is destroyed by canal anatomy—specifically parallel walls, curves, ovals, and transportation of the canal with stiffer instruments

Tapered Instruments make Lousy Tape Measures

How do we know when we have successfully cleaned the canal? Over the years there have been many methods proposed to determine, when the canal has been properly prepared. By feel: the classic step-back technique when you first feel the file bind at working length (WL) then go up an additional two to three files sizes to "clean" the canal at WL. This is followed by a few additional files in a "step back" fashion to clean the critical apical region of the canal.

This goes along with another classic gauging technique: the canal is clean when the file tip brings up clean white dentin chips. Presumably if the chips are clean, then the canal must also be clean. Unfortunately, Haga reported back in 1968 that these techniques are less than 20% effective in actually cleaning the canal.[4]

A newer procedure adapted for the modern crown-down techniques is called apical gauging. In theory, it seems logical, but let us look at this more closely. The theory says that if you take a larger tapered instrument to WL, then insert a 0.02 tapered hand file to WL and it binds, the tip size of that 0.02 tapered hand instrument has "gauged" the canal. That is your final apical size (FAS) (Fig. 2).

A recent modification of this theory is that if you are filling the apical flutes of a tapered rotary instrument with debris, it is cutting in the critical apical region and the canal

Table 1: Tapered instruments make lousy tape measures

Gauging technique	*Inaccurate because*
By "feel" or "binding"	– Taper binds while cutting into parallel canal walls – Taper binds in curves – Taper transports canals - more binding errors
By bringing up "clean" white dentin chips or filling apical flutes with debris	– Starting to clean at the minor diameter of oval canals while ignoring the major diameter, the working width – Cutting into apical curves and transporting the canal
By using canal size averages	– As ludicrous as measuring WL with averages

is clean. Presumably by preparing the canal with a greater-tapered instrument, additional preparation with two to three larger sizes at WL is eliminated.

Unfortunately, canals just don't cooperate with these gauging theories (Table 1). With very few exceptions, consider all canals as being curved.[5] Also, with very few exceptions, consider all canals exiting short of the anatomical apex, often at an acute angle.[3] There is some physiological logic to this. If the canal exited straight out the apex, pulpal tissues could be damaged during mastication. By exiting out the side of the root, it avoids direct compressive forces against nerve-rich pulpal tissues. Additionally, canals have mostly parallel walls and are oval when viewed in cross-section.[6,7] These oval-shaped canals have both a minor and major diameter. The authors also report that 20 to 40% of the ovals have a two-to-one ratio or

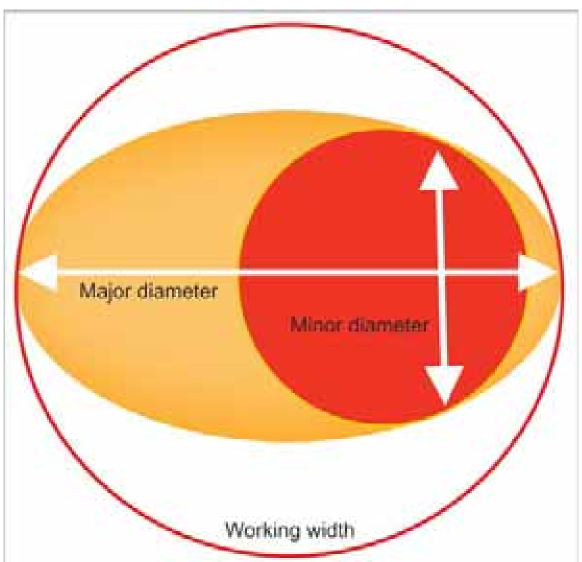


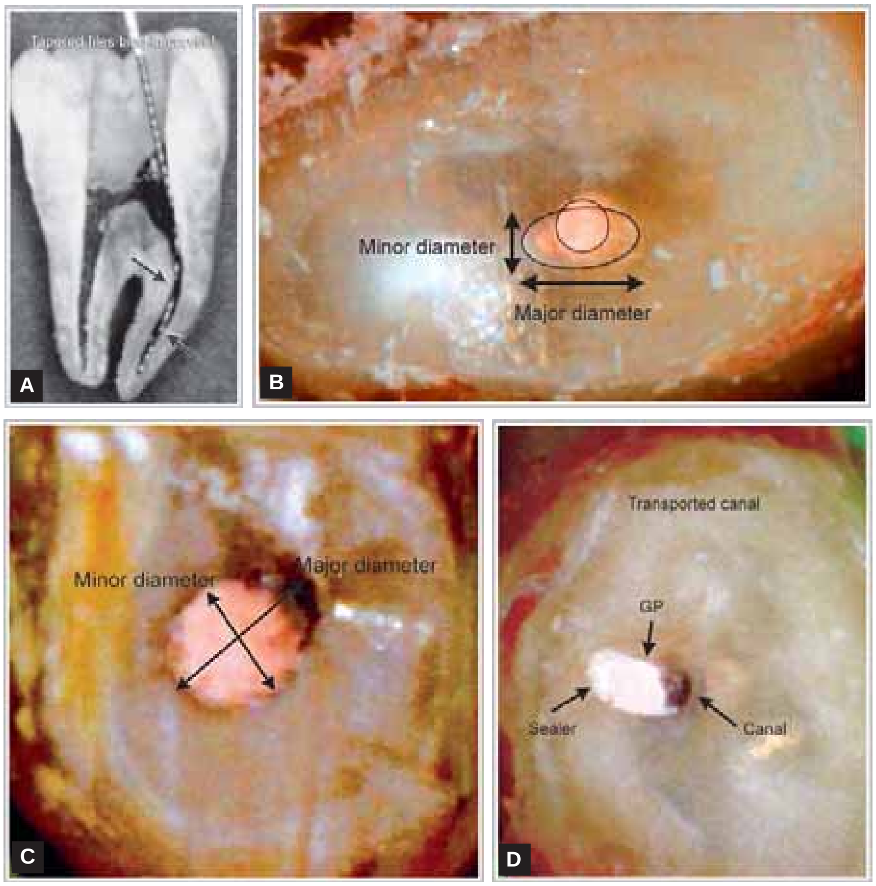
Fig. 3: Canals are basically oval in cross-section and have major and minor diameter. Gauging techniques are inaccurate mainly because instruments bind in the minor diameter, leaving a lot of debris and bacteria in the wider major diameter to cause pain and failures in the future

more of major to minor diameter. The major diameter is also called the working width (WW) (Fig. 3).

So, how do curves, parallel walls, and ovals turn tapered instruments into lousy instruments for measuring when you have removed pain-causing debris and bacteria? Tapered instruments are designed to create taper—that was a hard one to figure out! When you add taper, you add stiffness. When you add taper, you lose apical tactile feedback—you lose feel. Imagine a tapered instrument going down canal walls that are basically parallel from orifice to apex. It cuts the canal walls until it has forced its shape onto the canal. Now add a curve or two to the equation. Tapered instruments bind in parallel walls and curves and give false feedback with the classic "it's binding in the canal so I must be done" theory.

Then, add the stiffness factor. How can you gauge the critical apical region when it is being transported? You can't, not accurately. When the instrument strays from the central axis of the canal it can leave larger portions of the canal walls untouched. Studies report a 48 to 90% transportation rate with tapered instruments.[8,9]

The next anatomical consideration that prevents accurate gauging and cleaning canals is their oval shape. From a cross-sectional perspective, instruments will first bind at the narrowest diameter of the canal, the minor diameter. Therefore, when you feel the instrument start to bind, it's just *starting* to do its job. So, how much larger do you go after the instrument starts to bind to clean the canal? You just don't know with tapered instruments. Then, there is the concern regarding safety. As you go up in size, the chances of ledging, perforation, and instrument separation greatly increase as well as your level of anxiety. So what are you really feeling? Where is the instrument really binding? Are you bringing up white dentin chips because the instrument has transported out of the original canal location (Figs 4A to D)? The lack of accurate tactile feel often leads one to



Figs 4A to D: Virtually all canals have parallel walls, and are curved and oval in shape. When you gauge the canal, does it bind in or bring up white dentin chips from: (A) the parallel wall or tangent of the curve, (B) the minor diameter of the oval, (C) The major diameter, or (D) The transported canal?

believe that they are doing a great job of cleaning the canal, and our radiographs seldom tell us otherwise. When the canal is not well cleaned, you set up the possibility of chronic inflammation, potential pain, failures, and possibly losing that person as a patient altogether.

The Average Mistake

Let's consider simplifying the determination of WL by using averages, classifying roots as short, medium, or long. Science tells us that a short molar root is on average 11 mm long (Fig. 5A).[10] With this simplified approach you could determine the WL of a molar canal simply by measuring the height of the anatomical crown and adding 11 mm. What time this technique would save! We wouldn't have to take WL determination radiographs or deal with foramen locators. Of course this idea is ludicrous, but it serves as an example of how ludicrous it is to use average apical sizes.

A series of 6 studies over 5 years analyzed canal cleanliness after instrumentation. Mesial canals of mandibular molars were instrumented to an average size of #45 with all of the well-known nickel titanium (NiTi) systems. The revealing result is "[In] none of the systems in the present study could an acceptable cleanliness of root canal walls be obtained."[11] These studies also showed a 9% "oops factor" with tapered instruments, including instrument separation and root perforation. So what does that say about the cleaning capabilities of techniques whose average apical preparation size for the mesial canals of mandibular molars falls well below size #45? Mesial canals of mandibular molars are considered to be "small" and the most popular techniques in practice today would have us end our preparations at a size #20 or #25, maybe #30 because it would be dangerous to go any higher with these instruments. Yet we know from research that canals are

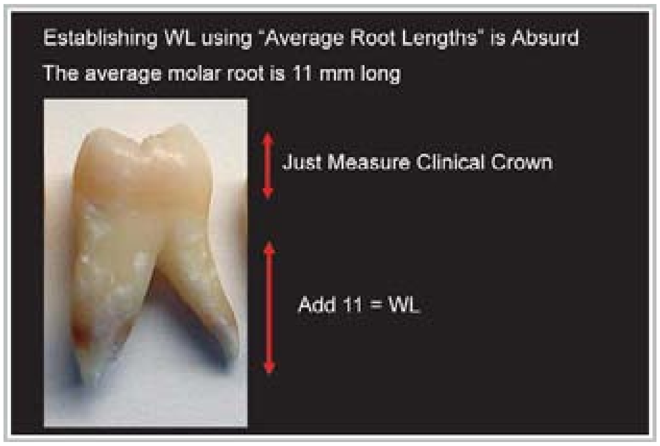


Fig. 5A: Using averages for WL is absurd, so why do we try to use averages for the WW of the canal?

Fig. 5B: This mesial-lingual canal is not the same size as the mesial-buccal and it takes only one canal to cause tooth failure

wider in diameter; therefore, we have a problem. Might this account for the many failures and persistent pain experienced by 50% of the dentists when asked about their own root canal experiences (Fig. 5B)?

Root canals are like feet in that for one to be comfortable, you must wear the right shoe size. Likewise, in order to properly clean each canal we must "match" our instruments to the size and shape of each specific canal. Instrumenting canals to standardized tapers and preconceived "average" diameters is the same as determining WL with my "simplified" approach. As absurd as my average WL example is, why do we settle for such approaches when it comes to determining the WW?

Should RCT Stand for Refer Canal Therapy?

For me personally, RCT stood for "refer canal therapy" until I fell into a unique situation about 11 years ago. Retiring from the military, I joined a group practice. They subsequently lost their endodontist and asked, if I would be the Internal Endodontic Resource – no way I thought, because for me RCT stood for refer canal therapy. Well, after some arm twisting, I finally accepted the position and took on the responsibility to find the best possible technique to treat our patients. I did a great deal of research and took many hands-on courses. During my literature review I found virtually nothing about complete debris and bacterial removal until I happened upon a hands-on endodontic course offered by LightSpeed Technology Inc. Whereas all the other courses I had taken focused on doing root canals faster and easier, LightSpeed focused on the primary goal of endodontics—safely removing all the debris faster, easier, and safer! They validated their technique at each hands-on course by cross-sectioning roots 1 mm from the WL, photographing them at 50X, and projecting the photos up on the screen for review and validation (Fig. 6). They punched holes in all the endodontic myths and conventional thinking I had been brainwashed into thinking was correct—mainly that creating a large tapered shape in the coronal portion of the root is necessary to get an adequate amount of irrigant down the canal and that keeping apical shaping to a minimum is desirable because it serves to keep obturation materials from being extruded out the foramina. This way of thinking is like the tail waging the dog. It minimizes the importance of getting the canals cleaned while

Fig. 6: 100% of canals cleaned round to WW were without clinical debris and had plenty of dentin left on all sides, like these first-time users of LightSpeedLSX after calibration and breaking out of old paradigms

focusing on shaping and obturation. Both of which are important but not nearly as important as getting the canals clean.

To prove to myself that these new "radical" concepts from LightSpeed were indeed true, I initiated a quest comparing tapered to non-tapered techniques in relation to total debris removal. Being an article reviewer, I thought it wouldn't be too hard to do a study. After 2 years of work, the results were published.[9] I found that when it comes to canal cleaning, our modern crown-down technique does no better than the step-back technique of Haga's research in 1968. Haga's study reported that the step-back technique cleaned all the walls in the critical apical region only about 20% of the time. My study revealed that only 18% of the time did the crown-down technique remove all the debris at 1 mm from WL.

Conversely, LightSpeed removed all the debris 100% of the time, but not enough teeth treated with LightSpeed had failed, and therefore there were not enough extracted teeth available for statistical analysis, which is significant in itself. Nonetheless, I could see with my own eyes how much better LightSpeed was able to clean canals when compared to the NiTi tapered rotary systems. When the canal was cleaned with LightSpeed to the correct WW, 100% of the debris was removed (Fig. 6). Conversely, canals not cleaned to WW were underprepared and had residual debris 97% of the time in the critical apical region (Fig. 7). Other findings were that irrigation was not able to remove missed debris in the critical apical region and that thermoplastic obturation followed the path of instrumentation and did not entomb residual debris. Bottom line, apical gauging was not accurate when tapered instruments were used, thus causing clinicians to significantly underprepare canals, leaving debris behind to cause postoperative pain and potential failures down the road.

Fig. 7: Conversely, when the canal was not cleaned to WW, 97% of the canals had residual debris. To reduce postoperative pain and ensure long-term success, debris and bacteria need to be removed as thoroughly as possible

What makes the LightSpeedLSX™ design (Discus Dental LLC) different from the traditional tapered instrument? LightSpeedLSX™ does not have taper or flutes along its shaft that force taper onto primarily parallel canal walls. The spaded shape of the LSX blade gives you great tactile feedback, indicating when it is cutting the minor diameter of the oval canal and again when it is cutting the major diameter (WW). Its non-cutting tip and taperless and flexible shaft makes transportation a non-issue. By staying centered in the canal and preparing to the WW, a recent study showed LightSpeedLSX™ was able to render canals 95% debris free in the critical apical region. When combined with EndoVac irrigation its effectiveness improved to 99.5%.[12] That is obviously a lot better than tapered instruments where only 18% of the canals were free of debris.[9] My experience tells me that this technique reduces postoperative pain and improves the success chances of the patients I treat. To borrow a phrase from Discus Dental, that is SMART Endodontics!

Are You Performing R-AC-T or RCT?

What does RCT stand for again? It does not stand for root apical constriction therapy. Cleaning the major canal diameter and not just the apical constriction diameter determines how much of the debris is removed from the canal. Since at least 1977, we have known that canals are much wider in diameter than we typically prepare them, but we are just now beginning to really appreciate it.[13-15] The diameters of apical constrictions typically range from 20 to 40 with an average of 30. Boy, does that sound familiar. Using average tapered crown down technique tip sizes of 20 for small canals, 30 for medium canals, and 40 for large canals equals R-AC-T (root apical constriction therapy). But canal diameters are typically much larger just 1 mm coronal to the constriction, from size 35 to 100 and higher. It is in this critical region "the apical third" that we need to focus our attention, where the case is treated successfully (or lost) and where WW and RCT are determined (Figs 8A and B).

In the past we had an excuse for not cleaning to the correct apical sizes—our stainless steel hand files just couldn't deal with large canal sizes safely. Even with the advent of NiTi, tapered instruments, we still cannot accurately gauge and clean canals to their proper WW. Now that we have non-tapered NiTi LightSpeedLSX™, we can safely gauge and clean to WW in the apical third.

Mandibular apical sizes (Working width)

Tooth and Canal	J Endodon 1977 Kerekes	Compondium 1991 Sabala	OOO 2000 Wu
Incisors	45 – 70	60	55
Canine	50 – 70	80	45
Premolar	50 – 70	45 – 80	40
Molar MB	35 – 45	45	45
ML	35 – 45	45	45
D	60 – 80	60	50

A

Maxillary apical sizes (Working width)

Tooth and Canal	J Endodon 1977 Kerekes	Compondium 1991 Sabala	OOO 2000 Wu
Central & Lateral	60 – 90	80	50 – 60
Canine	50 – 70	80	60
Premolar	35 – 90	45 – 80	40 – 65
Molar MB	35 – 60	45	35 – 50
DB	40 – 60	45	35
P	80 – 100	60	40

B

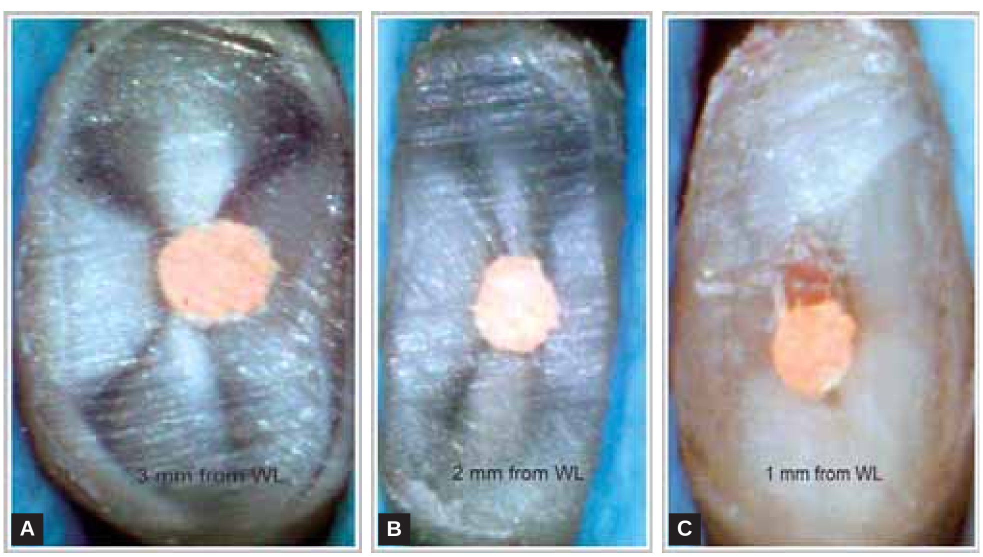
Figs 8A and B: SMART Endodontics is all about root canal treatment. Individual canal sizes range from 35 to 100. Traditional techniques focus on apical constriction treatment, which limits apical preparation sizes to a range from 20 to 40

Moving Forward by Going Backward?

I find it interesting that many of those who appreciate that we have to clean to actual root canal sizes are trying to do so by going backward. They are using the largest tapered instrument they safely dare to, then "finish" apical instrumentation with larger hand files. A great example of that can be seen in Figures 9A to C. After an endodontist performed RCT on this acute premolar, it continued to cause pain for over a year and a different endodontist cleaned it to a larger size. He used a NiTi tapered rotary (#30 tip size with 0.09 taper) and finished the canal to a # 50 hand file (0.02 Taper). The patient was still experiencing pain, so the endodontist suspecting a crack, referred the patient to me for extraction. I kept the tooth and performed cross-sectional analysis. There were no cracks in the tooth. The tapered instruments cleaned the canal just fine to a depth of 3 mm short of WL, but the canal was under-cleaned and transported, leaving debris at 1 mm from WL. The tooth could probably have been saved, if the canal had been prepared properly in the critical apical third to both the correct WL and the WW.

Debris Removal and Postoperative Pain

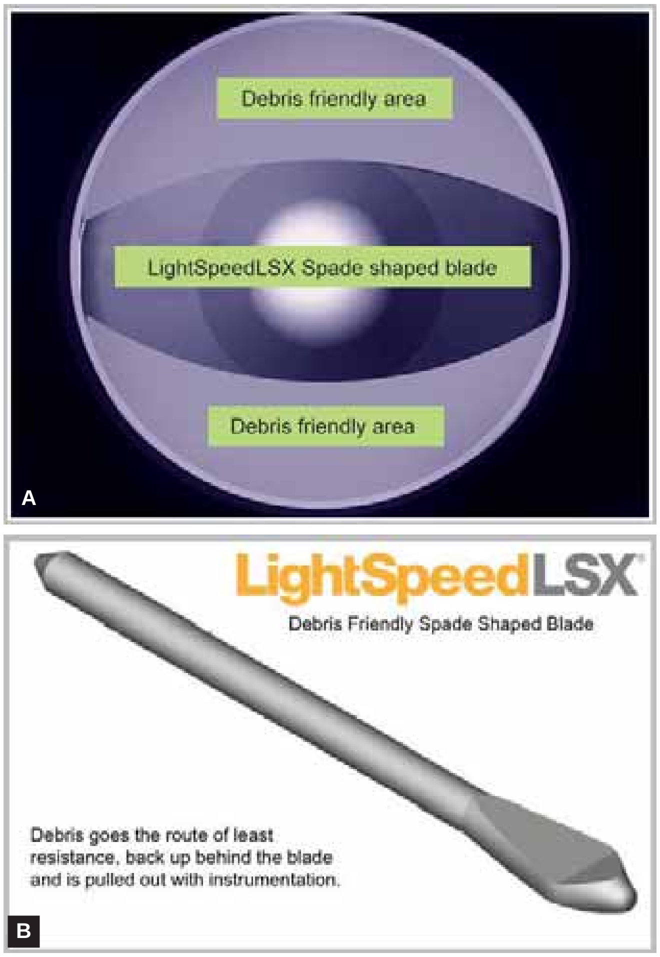
When I give post-RCT instructions, I inform patients that there are two sources of pain, from the inside nerve and the outside nerve. The reason the tooth is still functional after RCT and why it can still be sensitive after the inside nerve is removed is due to the outside nerve, called the periodontal



Figs 9A to C: Going backward to go forward failed to clean this canal, leading first to chronic pain, then to extraction

Table 2: Moderate postoperative pain

Technique	*Day 1*	*Day 2*	*Day 3*
K-file step back	28%	30%	53%
Balanced force (a crown-down technique)	15%	22%	48%
LightSpeedLSX™	7%	3%	0%



Figs 10A and B: The taperless shaft and debris-friendly spade-shaped blade of LightSpeedLSX™ results in half to a quarter the immediate postoperative pain reported for other techniques. The inflammatory response 3 days out is 0% for LightSpeedLSX™, whereas it is about 50% for the other techniques

ligament (using a little creative license for the lay person here). I explain that most of the debris we create while cleaning out the canal comes out the opening in the top of the tooth, but some gets pushed out the end. It can create pain in two ways. First by direct trauma, like getting kicked in the shin, and second by delayed pain, about 3 days later, from inflammation caused by debris being pushed out the canal. Clinically, I have found that using LightSpeedLSX™ has resulted in a lot less postoperative pain than when I used tapered techniques. This is supported by the results of a 2009 postoperative pain study, summarized in Table 2.[16]

Vieyra[16] discusses the importance of debris removal without extrusion out the canal. If we adhere to the theory that extruded debris causes postoperative pain, LightSpeedLSX™ results in half to a quarter less debris extrusion pain after day one and 0% inflammatory pain at day three versus about 50% for the other techniques tested. This can easily be explained with fluid dynamics—fluids follow the path of least resistance. Imagine the impact of tapered instruments working their way down a basically parallel-walled canal. The tapered instrument's mid-flutes bind against parallel walls and curves and are filled with debris. When the tip advances forward, the debris has nowhere to go but apically (the path of least resistance). LightSpeedLSX™ avoids this because its apical end is the largest part of the instrument and the coronal end is the smallest. With no taper and a debris-friendly spade-shaped blade, debris backs up behind the blade and is removed upon instrument withdrawal (Figs 10A and B) and EndoVac irrigation.

Part two of this article, scheduled to appear in the May/June issue of Endodontic Practice US, Vol 3.3, addresses the topic of irrigation and pain and how it is critical to successful RCT. Several pain-reducing cases are included and techniques to avoid repetitive stress trauma to your hand are discussed, as well as techniques to safely achieve WL in sclerotic canals.

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