

ENDODONTIC DISINFECTION

THE SONIC ADVANTAGE

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In the United States, alone, more than 100,000 dentists perform tens of millions of operative, restorative, and reconstructive procedures on an annual basis. Certainly, these dental procedures are primarily directed toward eliminating carious lesions, esthetically restoring teeth, and functionally moving patients toward optimal oral health. However, it is well recog-



Figure 1. This graphic demonstrates that lesions of endodontic origin (LEOs) arise secondary to pulpal breakdown and form adjacent to portals of exit (POEs).



Figure 2a. A pre-operative film of a maxillary first bicuspid. Note a gutta percha cone tracing a sinus tract to a LEO.

nized that repeated dental procedures on the same tooth potentially contribute to irreversible pulpal injury. Pulpal breakdown originates within an anatomical space that commonly exhibits infinite configurations along its length. As such, the endodontic treatment challenge is 3D disinfection.

Root canal systems contain branches that communicate with the attachment apparatus furcally, laterally, and often terminate apically into multiple portals of exit (POEs).¹ Consequently, any opening from the root canal system to the periodontal ligament should be thought of as a POE through which potential endodontic breakdown products may pass (*Figure 1*). Radiographically, it is fundamental to associate that a lesion of endodontic origin (LEO) arises secondary to pulpal breakdown and forms adjacent to any given POE. Improvement in endodontic treatment occurs with the recognition that anatomy matters and that 3D disinfection of the *root canal* system is central to predictably successful endodontics (*Figure 2*).²

ENDODONTIC OBJECTIVES

A LEO will invariably heal following an extraction because this procedure not only removes the tooth, but importantly serves to eliminate 100% of the contents of the root canal system.



Figure 2b. A recall image reveals excellent healing and confirms the importance of shaping canals, 3D disinfection, and treating root canal systems.

Like the extraction, the biological objectives for endodontic treatment are to remove all the pulp, and bacteria when present and their related irritants, from the root canal system. Treatment is directed toward making a correct diagnosis, isolating the tooth, and preparing an effective access cavity. Importantly, any given canal is manually reproduced, secured, and shaped to facilitate both 3D cleaning and filling root canal systems. Certainly, endodontically treated teeth should be properly restored to protect against hopeless fracture and achieve a coronal seal (**Figure 3**).

Further influencing 3D disinfection is to recognize that the files utilized to prepare canals produce debris and do not clean into the uninstrumentable portions of a root canal system (**Figure 4**). This debris, or smear layer, is oftentimes a cocktail containing dentinal mud, pulpal remnants, and when present, microorganisms. Importantly, a smear layer serves to limit or completely block the exchange of an irrigant into the uninstrumentable aspects of the root canal system. In the noble quest toward complete 3D cleaning or disinfection, many reagents, devices, and methods have been advocated and utilized.³ This article will emphasize the importance of active irrigation. Let's get started!

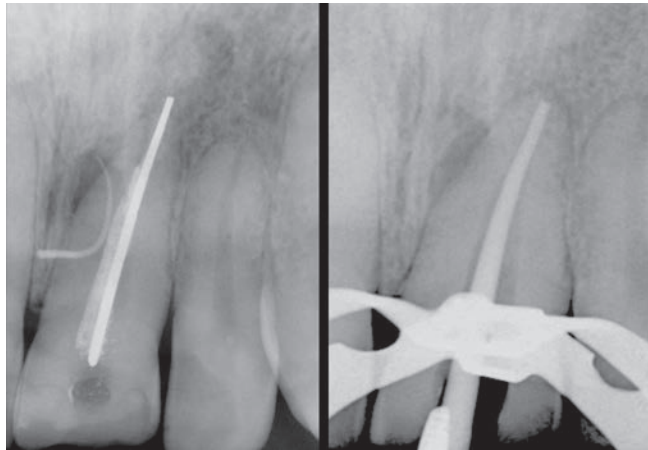


Figure 3a. Left: A pre-operative film demonstrates a failing central incisor with a gutta percha point tracing a sinus tract to a lateral LEO. Right: Following disassembly and 3D cleaning, a working film demonstrates master cone fit.

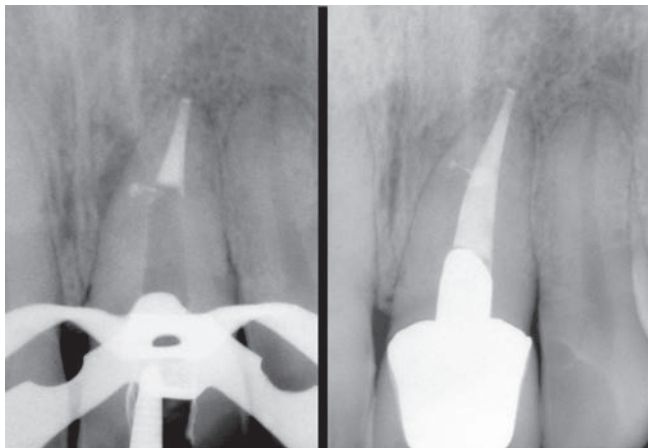


Figure 3b. Left: This working film image demonstrates the downpack. Note the filled lateral canal associated with the laterally positioned LEO. Right: A 25-year recall film demonstrates 3D endodontics, osseous repair, and the restored tooth.

ACTIVE IRRIGATION

Using best technologies, active irrigation serves to initiate fluid hydrodynamics, resulting in shear wall forces that wipe surfaces clean. There is increasing evidence to support that fluid activation, in both minimally or more fully shaped canals, plays a strategic role in exchanging irrigant, which in turn, serves to disinfect into all aspects of the root canal system, including lateral canals, loops, fins, webs, anastomoses, and dentinal tubules.²⁻⁴ The greatest focus today is on how to safely, effectively, and efficiently activate any given reagent to maximize the hydrodynamic phenomenon. The most important reagents for activation are solutions of 6% NaOCl and 17% EDTA, recognizing other final rinse solutions are available.

ACTIVE IRRIGATION METHODS

There are 3 primary methods that have been shown to exchange an intracanal irrigant into all aspects of the root canal system: namely, acoustic energy, light energy, and mechanical energy.³ Although acoustic and light-based technologies are intriguing, their widespread adoption into the marketplace is limited, as both of these technologies are priced from several thousand to tens-of-thousands of dollars. The following will describe a mechanical technology for 3D disinfection that best combines scientific evidence, effectiveness, and affordability. The EndoActivator (*Dentsply Sirona*) is validated by more than a dozen scientific, peer-reviewed articles. Further, it is used by nearly 50,000 international dentists and is readily affordable in North America at a cost of about \$500 for the introductory kit and less than \$2.00 per patient.

ENDOACTIVATOR SYSTEM

The EndoActivator is a mechanical system that is comprised of a handpiece and variously sized polymer tips (**Figure 5**). This sonically driven system has been engineered to safely activate various intracanal reagents and vigorously produce the hydrodynamic phenomenon. As we will see, this technology provides a safer and more effective method to disinfect a root canal system compared to ultrasonic technology.⁴⁻⁶ When the directions for use are followed, research continues to show

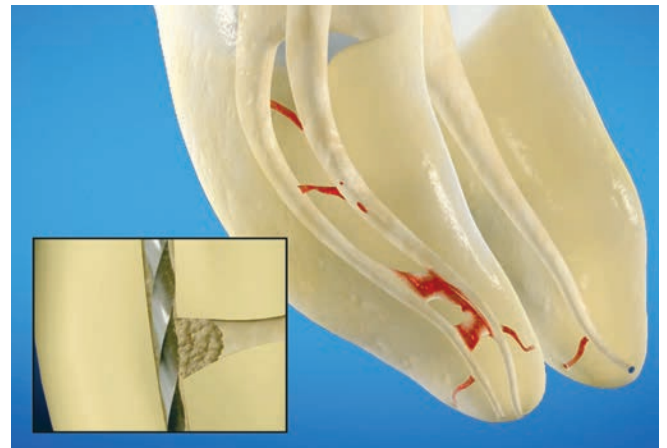


Figure 4. This graphic shows residual tissue following shaping, while the inset image depicts a file generating debris, resulting in a blocked lateral canal.



Figure 5. The EndoActivator System is designed to safely and vigorously exchange intracanal reagents into all aspects of the root canal system.

that the EndoActivator system is able to remove the smear layer, debride into the uninstrumentable portions of the root canal system, and dislodge biofilms within long, narrow, and highly curved canals of molar teeth (**Figure 6**).⁶⁻¹⁰

SONIC HANDPIECE

The sonic handpiece has been designed to be cordless, contra-angled, and ergonomic, and is used to mechanically drive strong and flexible polymer EndoActivator tips. When the handpiece is activated, the power defaults to 10,000 cpm, which research has shown significantly promotes all aspects of 3D disinfection.^{4,6-7} Depending on use, a new, single lithium battery is periodically replaced to ensure optimal performance. For infection control, custom protective barrier sleeves have been designed to easily slide over the entire handpiece. After use, it is important to *not autoclave* or *submerge* the handpiece in cleaning solutions; rather, remove the barrier sleeve and simply wipe down the handpiece with a mild detergent.

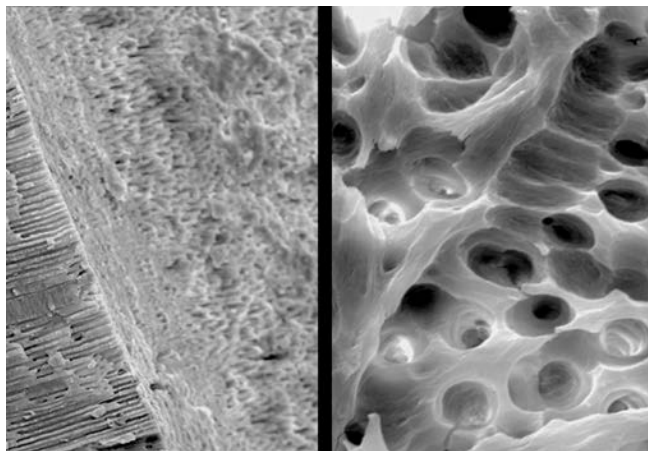


Figure 6. SEM images provide evidence that the EndoActivator System can clean root canal systems (courtesy of Dr. Grégory Caron; Paris, France).

ENDOACTIVATOR TIPS

The EndoActivator tips have an easy snap-on/snap-off design and are color-coded yellow, red, and blue to approximately correspond to file sizes 20/02, 25/04, and 30/06, respectively. The tips are made from a noncutting, medical-grade polymer, are strong and flexible, and are 22 mm long with orientational depth gauge rings positioned at 18, 19, and 20 mm. The EndoActivator tips are disposable, single-use devices that *should not* be autoclaved. Autoclaving an EndoActivator tip reduces the elasticity of the tip, which decreases its back-and-forth movement and performance. The EndoActivator tip selected is placed over the barrier-protected driver and is simply snapped on to secure its connection to the handpiece (**Figure 7**).

Tip Selection

In well-prepared canals, it is easy to select a tip that fits loosely to within 2 mm of working length.^{1,11} When a tip is too big for any given prepared canal, its back-and-forth movement will be restricted or dampened, limiting its ability to agitate a solution. Research has shown that vibrating the tip, in combination with moving the tip up and down in short 2-3 mm vertical strokes, synergistically produces a powerful hydrodynamic phenomenon.^{4,6-7} Scientific evidence supports that this specific technology optimizes debridement, eliminates the smear layer, and disrupts biofilms (**Figure 6**).⁶⁻¹⁰

CLINICAL PROTOCOL

Following shaping procedures, re-irrigate and flush the root canal space with a 6% solution of NaOCl, then suction to remove this reagent. Next, flood the pulp chamber with a 17% solution of EDTA and use the EndoActivator to agitate this intracanal solution for 60 seconds. This process should be repeated for each canal or until the fluid in the pulp chamber is clinically observed to be clear. Following the use of 17%



Figure 7. A pre-selected EndoActivator tip is placed over a protective barrier and snapped onto the handpiece for clinical use.



Figure 8a. This clinical image shows the EndoActivator in use. Note the powerful activation of fluid and appreciate the suborifice potential for 3D cleaning.

EDTA, vacuum and remove this reagent. Irrigate with a 6% solution of NaOCl and use the EndoActivator to agitate this intracanal solution for 30 seconds (**Figure 8**). When the clinical procedure has been completed, the single-use activator tip and barrier sleeve should be discarded. To better understand the clinical use of the EndoActivator, animations, clinical ops, and published articles are available at www.endoruddle.com.

MECHANISM OF ACTION

In a well-shaped and fluid-filled canal, the hydrodynamic phenomenon results when a vibrating tip generates fluid activation and intracanal waves.^{3-4,9,11} Random waves fracture, resulting in the formation of bubbles that oscillate within any given reagent. These bubbles expand, become unstable due to heat and pressure, then collapse and implode. Each implosion generates up to 30,000 shockwaves that serve to powerfully penetrate, break up potential biofilms, and wipe surfaces clean.⁴ This phenomenon is regularly visualized clinically, as the action of the EndoActivator tip frequently produces a cloud of debris within a fluid-filled pulp chamber.

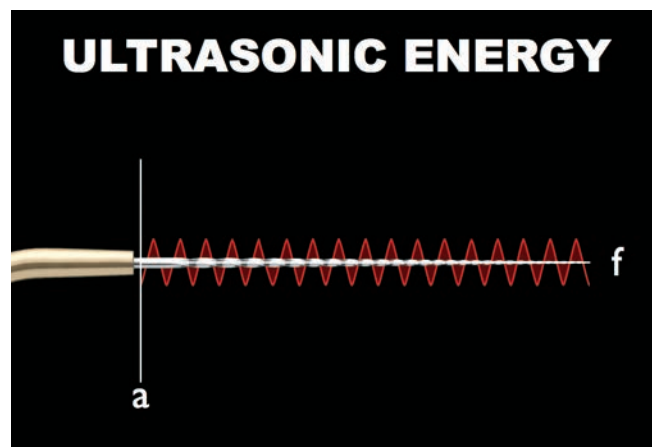


Figure 9a. This image illustrates a sinusoidal wave of ultrasonic energy propagating along a metal screw-on tip. Note the high frequency and ultra low amplitude.

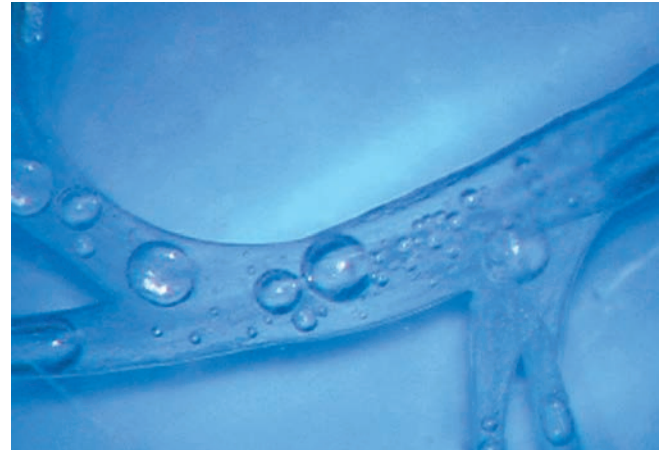


Figure 8b. This image depicts a simulated root canal system. The Activator tip is used with a gentle pumping motion to enhance the exchange of irrigant.

THE SONIC ADVANTAGE

The EndoActivator is a sonic technology that has been shown to be superior to ultrasonic technology utilized for 3D disinfection.^{3-4,6} The following will look at the distinct sonic advantages that independently and synergistically influence fluid activation.

AMPLITUDE AND FREQUENCY

Amplitude is the maximum value of back and forth displacement of a vibrating tip. *Frequency* is the interval of time it takes a vibrating tip to move through one complete back-and-forth displacement cycle. In general, the higher the frequency, the lower the amplitude. Certain distributors market activating metal insert tips at high ultrasonic frequencies for endodontic 3D disinfection. However, an ultra high frequency requires an ultra low amplitude to mitigate tip breakage. To clarify, when ultrasonic energy is used for 3D disinfection, high frequency sinusoidal waves are produced with low amplitude, meaning less useful energy. On the contrary, sonic technology produces a high tip amplitude about 60 times greater than ultrasonic technology (**Figure 9**). Re-

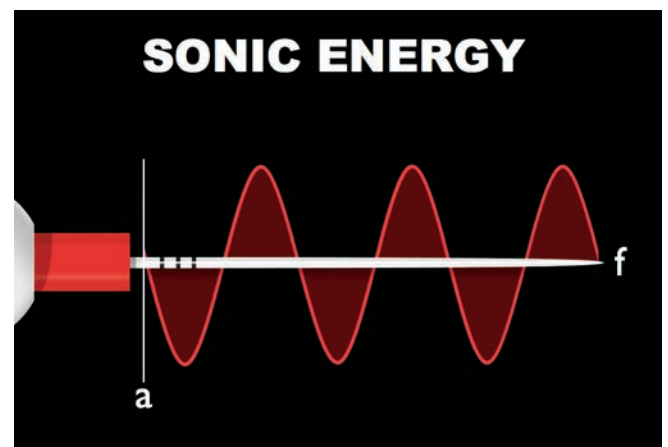


Figure 9b. This image illustrates a sinusoidal wave of sonic energy propagating along a polymer snap-on tip. Note the low frequency and ultra high amplitude.

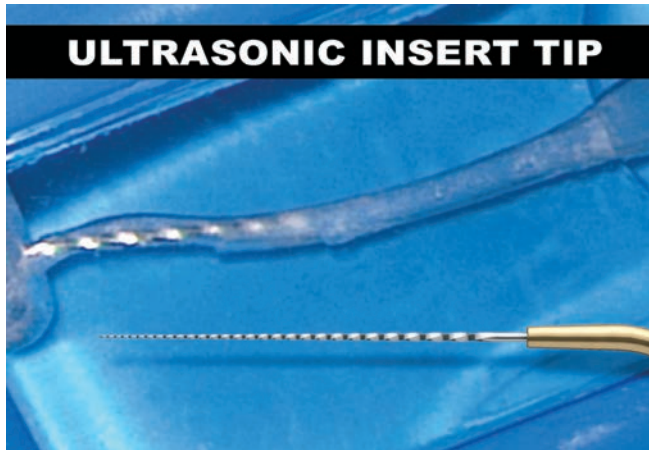


Figure 10a. In this plastic S-block, vibrating a metal insert tip around canal curvatures predisposes to ledges, an apical transportation, and a broken insert tip.

search shows this amplitude maximizes hydrodynamics and 3D disinfection.^{3-7,12-14}

NONCUTTING

Sonic technology drives highly flexible, noncutting, polymer tips that absolutely maintain the anatomical integrity of the final preparation.^{4,14} On the contrary, all ultrasonically driven instruments are manufactured from metal alloys. Appreciate that ultrasonically driven instruments are either active and have cutting edges, or are nonactive in that their cutting edges have been reduced or eliminated. Regardless, any active or nonactive metal-driven ultrasonic insert tip that contacts dentin will cut dentin and generate its own smear layer. Of greatest concern, vibrating any metal tip, even pre-curved, around a canal curvature invites ledges, apical transportations, lateral perforations, or broken instruments (**Figure 10**).¹⁴⁻¹⁵

CONTINUOUS MOVEMENT

It should be understood that any vibrating tip will almost certainly contact dentin because of the various dimensions and curvatures of any given final preparation. Research has shown that, when a sonically driven polymer tip is constrained against a dentinal wall, the tip advantageously continues to

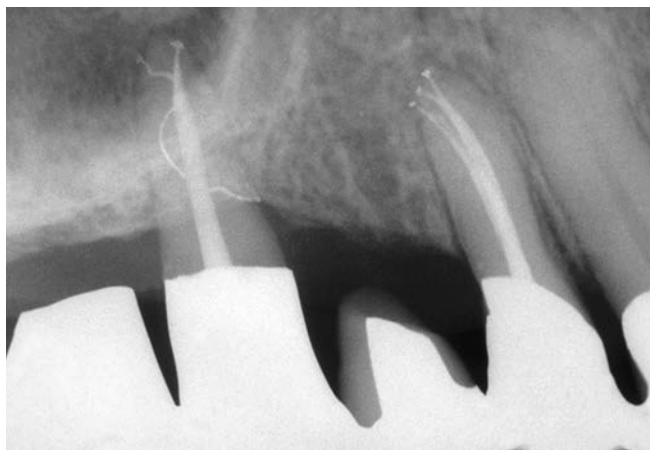


Figure 11. A long-term recall radiographic image demonstrates a lone palatal root successfully serving as a peer abutment under a 6-unit splint.

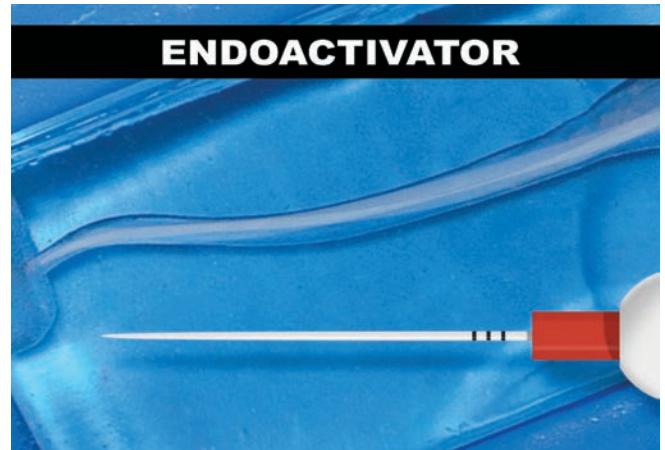


Figure 10b. In this plastic S-block, vibrating a polymer and noncutting EndoActivator tip maintains the anatomical integrity of the final preparation.

display a large displacement amplitude.¹² To validate this phenomenon, simply turn on the EndoActivator handpiece, purposefully constrain, at any level, the moving tip, and note that the tip will continue to vigorously move! On the contrary, constrain a vibrating ultrasonic insert tip and note the tip movement will be sharply reduced or the tip will not move at all.¹³ It is appreciated that a loss of tip movement will compromise the exchange of irrigant.

CLOSING COMMENTS

Discounting radicular fractures, the sum of all endodontic failures is directly related to bacterial infection due to deficiencies in primary treatment. As such, 3D disinfection is central to predictably successful treatment. Clinicians should be skeptical and dismiss marketing claims that state ultrasonic technology for 3D disinfection is faster and somehow better; it is well known that activating metal insert tips at a high speed is dangerous. In the current state of 3D disinfection, the EndoActivator is an effective, affordable, and scientifically proven technology that uses safe, flexible, and noncutting polymer tips. Catch the sonic wave and recognize a clean root canal system is an opening for 3D obturation and long-term success (**Figure 11**). ▲

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