Advancements in Root Canal Therapy: New Technology to Improve Patient Outcomes

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ABSTRACT
Success rates for endodontic procedures can be quantifiably and qualitatively improved with the use of new multisonic technology, which provides a far more conservative and thorough methodology than common root canal procedures. Using multisonic technology, the clinician can achieve the five mechanical objectives initially proposed by Dr. Herbert Schilder. The system allows the clinician to transition from a sense of “cleaning and shaping” to “preparing” the root canal system. Overall, advantages can be found in reduced clinical fatigue and decreased discomfort for the patient. The authors conclude that multisonic technology enables the clinician to provide a higher level of care that better accounts for the complexity of the root canal system.

LEARNING OBJECTIVES
• Describe the principles underlying root canal therapy and mechanical objectives.
• Discuss the endodontic procedure protocol for a new technology.
• Explain the advantages of using the new technology.

A clinician’s endodontic success rate can be difficult to determine, either in the long or short term. Complications of root canal anatomy can make success difficult to gauge. The main opportunity that clinicians can take advantage of regarding root canal system anatomy relates to microanatomy. This article will provide an overview of root canal system anatomy and historical root canal therapy. It will then introduce multisonic technology, which can dramatically improve endodontic outcomes for patients. This technology enables clinicians to be more conservative in their treatment and achieve greater case success.

ENDODONTIC SUCCESS AND THE ROOT CANAL SYSTEM
Some dentists are familiar with the 1917 study of the root canal system that was brought to the United States in 1925 by Walter Hess. The study set the benchmark for the modern understanding of dental anatomy, but it also created limitations, because of the concept of a single “root canal.” A better concept for this anatomy is root canal “systems,” a term introduced by Dr. Herbert Schilder in 1974. Today, a cursory Google search will provide incredibly detailed displays of digitized micro computed tomography (CT) of root canal system anatomy. These images demonstrate the complexity of root canal systems, which can be compared to a fingerprint because of their person-specific nature. Figure 1 provides a representation of a lower premolar micro CT that makes it clear how difficult the endodontic clinician’s task of cleaning and shaping such an intricate system can be. This complexity also illustrates why clinicians may be falling short of fully debriding and disinfecting these anatomical systems regardless of what instruments and irrigation protocols are utilized.

Irrigation methods have changed over time, transitioning from passive irrigation to active irrigation. Gutta-percha cone activation gave way to the EndoActivator® (Dentsply Sirona, dentsplysirona.com) by Dr. Clifford Ruddle, which opened the door for moving irrigants more effectively throughout the root canal system. Next came ultrasonic activation technologies, including PiezoFlow® (Dentsply Sirona), EndoVac® (Kerr Dental, kerrdental.com), and, more
recently, EndoVac Pure™ (Kerr Dental), which have collectively helped clinicians to realize the value of active over passive irrigation. In the 1970s and early 1980s, dental school education for root canals did not consider the system view. This limited perspective later shifted, as exemplified by Schilder’s article, “Cleaning and Shaping the Root Canal.” In a key quote from this article, Schilder states, “Initially, root canals were manipulated primarily to allow placement of intracanal medicaments, with little attempt to remove completely the organic contents of the root canal system. In spite of elaborate modifications over the years, many methods of preparing root canals mechanically still fail to cleanse root canal systems effectively.”

Schilder, whose thinking was forward-looking, provided five mechanical objectives. These five objectives were reduced to four by Ruddle: continuous tapering preparation, original anatomy maintained, position of foramen maintained, and foramen kept as small as practical. With new, disruptive root canal treatment technology currently on the market, the objective of a continuous tapering preparation is, in the opinion of these authors, perhaps no longer necessary. Throughout the history of endodontics, there have been many times when a new technology challenged the status quo, was dismissed or disliked, but then became the norm. Microscope technology that emerged in the early 1990s and cone-beam computed tomography (CBCT)/three-dimensional (3D) imaging are examples of disruptive technologies that were met with skepticism but have now become commonplace.

**ADVANCED ROOT CANAL TECHNOLOGY**

The new technology introduced in this article is based on advanced multisonic technology. Several current systems take advantage of ultrasonics and/or piezoelectric ultrasonic technology to deliver endodontic therapy. Some of these include MiniEndo™ (Kerr Dental), Varios® (NSK, nskdental.us), and Newtron® (Satelec, A-dec Inc, a-dec.com). The cases documented in this article feature the GentleWave® System (Sonendo®, sonendo.com), which employs a proprietary multisonic cleansing technology to deliver therapeutic irrigants into the root canal system, including lateral canals and tubules of complex root canal systems, while leaving the dentin largely intact. In the case shown in Figure 2 (preoperative radiograph) and Figure 3 (postoperative), the clinician was initially under
the misconception that simple “cleaning and shaping” could be used for the root canal system in the conventional manner. The clinician evaluated the root canal system digitally in 2D and 3D before starting the case. The case was accessed, prepared, and cleaned and disinfected. Special attention to the digital imagery of the mesiobuccal root complex allowed the clinician to appreciate that the MB1 and MB2 merged before exiting from a common foramen. The 2D postoperative radiograph (Figure 3) illustrates that all of the mechanical objectives were realized.

Figure 4 shows another preoperative radiographic image. The clinician was especially interested in observing what would happen in the apical one-third of the distal canal. Figure 5 shows the cone-fit radiograph, and Figure 6 shows the postoperative 2D image. The introduction of multisonic technology allowed the clinician to preserve more dentin while keeping the access more conservative.

Figure 7 shows another tooth that was diagnosed with a necrotic pulp; Figure 8 shows a preoperative CBCT slice from the volumetric scan of the tooth. The clinician observed that there was more than one canal in the mesiobuccal system and that a periapical lesion was present. Lesions were visible radiographically on every root, adjacent to numerous portals of exit in the apical one-third. In this case, the clinician aimed to be more conservative and was able to better maintain the original anatomy. In the mesiobuccal root, the canals crisscrossed, and considering the delicate anatomy in the apical one-third, it was imperative to keep the foramen as small as practical. A much larger palatal canal was also observed. The clinician provided a coronal seal buildup before the rubber dam was removed from the tooth. Figure 9 shows the postoperative 2D radiograph.

Figure 10 is from a case on the upper arch, tooth No. 3. On the distal buccal area, superimposed over the palatal and distobuccal root, there was a large periapical lesion. Figure 11 shows the preoperative CBCT slice. The tooth had preoperative draining via a sinus tract through the buccal plate that the clinician was able to appreciate before initiating the procedure. These images clarify the amount of bone destruction periapically, in the axial view. Recognition of the preoperative indicators enabled the clinician to consider how to best proceed with treatment. Figure 12 shows the postoperative 2D radiograph, which reveals a delicate buccal system and significant anatomy in the palatal canal. There was some extrusion of sealer palatally and at other portals of exit. Figure 13 shows a 3-week postoperative recall 2D radiograph of the case.
The draining sinus tract had healed by that point in time.

Figure 14 and Figure 15 show the preoperative digital images for another case with a necrotic pulp. In the preoperative 3D CBCT volume, the clinician observed that the mesiobuccal system, distobuccal system, and palatal system all communicated. On evaluating the mesiobuccal system, the clinician observed anastomoses between the canals. The clinician sought to employ a conservative approach to treating the case. Figure 16 and Figure 17 show the postoperative scans wherein it can be seen that the clinician practiced “directed dentin conservation” (a term attributed to Dr. David Clark and Dr. John Khademi and perpetuated by Dr. Eric Herbranson). The only mechanical objective not illustrated by this case is the continuous tapering preparation. Overall, the original root canal system anatomy was maintained and the foramen was kept as small as practical. Figure 18 shows an inverted postoperative radiograph that better illustrates both of these principles.

Figure 19 and Figure 20 illustrate a premolar in which the condition of the pulp was initially misdiagnosed and the patient was referred for restorative work. She returned within a few months, explaining that her tooth hurt. The clinician found that the pulp of tooth No. 12 was necrotic and the tooth had multiple portals of exit and multiple lesions of endodontic origin adjacent to these portals of exit. Figure 21 shows the postoperative 2D radiograph.
of the tooth after multisonic technology was used to clean and debride the microanatomy.

ADVANTAGES OF THE TECHNOLOGY

In the authors’ experience, the multisonic procedure does not take appreciable additional time and, in most cases, can be completed in a single-visit appointment. Clinician, staff, and patient fatigue are noticeably decreased because the process requires less time in shaping/preparation of the root canal system. In lieu of shaping of the root canal system, the clinician’s objective is solely to create a pathway to allow the multisonic technology to deliver degassed irrigants to the entire root canal system. The potential for instrument fatigue is reduced because the clinician does not attempt to enlarge the systems significantly beyond the natural anatomy. Instrument stress is lessened, resulting in fewer separated instruments and reduced anxiety for both clinician and staff. There is decreased schedule disruption and reduced loss of valuable tooth structure.

Employment of this technique alleviates the need for multiple instrument passage and repeated
recapitulations. As a result, this procedure dramatically lessens the production of the smear layer, leading to cleaner systems and more thorough debridement.

The technology involves a less-invasive technique with smaller, more conservative shapes. Less patient time is required because it is predominantly a single-visit procedure. The authors have found that only rarely will a case require placement of calcium hydroxide or an intra-appointment medicament. Postoperatively, the procedure results in less pain, less sensitivity, no swelling, and little to no discomfort; over-the-counter non-narcotic anti-inflammatory medications are all that are necessary postoperatively for most patients.

CONCLUSION
Success rates for endodontic procedures can be quantifiably and qualitatively improved with the use of new technology. Multisonic treatment advances root canal therapy and supports improvements to endodontic outcomes for patients. It accomplishes this through a far more conservative and thorough method than traditional root canal procedures. Using this modality, the clinician can achieve the five mechanical objectives determined initially by Schilder. This allows the clinician to transition from a sense of “cleaning and shaping” to “preparing” the root canal system. Overall, success can be measured by the reduction of clinical fatigue, a decrease in discomfort for the patient and improved healing rates, enabling the clinician to provide a higher level of care that better addresses the complexity of the root canal system.

REFERENCES
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1. What makes root canal therapy difficult to gauge?
   A. the lack of a recall appointment
   B. the inability to access the pulp chamber
   C. complication of root canal anatomy
   D. the high percentage of retreatments based on national data

2. The limitation of the 1917 study by Hess was because of:
   A. the concept of a single “root canal.”
   B. the concept of complex root canal anatomy.
   C. the concept of multiple small apices on virtually all teeth.
   D. the lack of applied scientific rigor to the study, leading to inflated conclusions.

3. The term root canal “systems” was introduced in 1974 by:
   A. Torbijnjad.
   B. Gow-Gates.
   C. Schilder.
   D. Kakehashi.

4. Root canal systems can be compared to a fingerprint because:
   A. they have a similar classification system in the United States.
   B. they have a similar classification system internationally.
   C. of their person-specific nature.
   D. of a consensus paper by endodontists in 2002.

5. More effectively moving irrigants through the endodontic system involves:
   A. passive irrigation.
   B. active irrigation.
   C. highly acidic irrigation.
   D. highly basic irrigation.

6. According to Schilder, many methods of preparing root canals mechanically:
   A. are considered effective about 40% of the time.
   B. are considered effective about 60% of the time.
   C. are considered effective about 80% of the time.
   D. still fail to cleanse the root canal systems effectively.

7. Schilder provided how many mechanical objectives when preparing a root canal?
   A. three
   B. four
   C. five
   D. six

8. This article describes a proprietary:
   A. endodontic shaping system.
   B. multisonic cleansing technology.
   C. endodontic length-measuring device.
   D. endodontic access-opening procedure.

9. Multisonic technology allows the clinician to:
   A. conserve more dentin while keeping accesses more conservative.
   B. conserve more dentin while making accesses larger.
   C. remove more dentin while keeping accesses more conservative.
   D. remove more dentin while making accesses larger.

10. Using a multisonic device decreases:
    A. clinician fatigue.
    B. staff fatigue.
    C. patient fatigue.
    D. all of the above
PROCEDURE PROTOCOL

In all patients, the clinicians’ first priority is to obtain an accurate pulpal diagnosis. The authors’ protocol for incorporating multisonic technology, such as the GentleWave® Procedure, begins with an initial examination and consideration of the patient’s dental history, systemic health history, and chief complaint.

Although several angled images and a bitewing radiograph may no longer be necessary, it is still advisable to take a straight-on 2D periapical radiograph. The second step is to take a preoperative 3D CBCT volumetric image. Following the achievement of profound pulpal anesthesia, a rubber dam is placed, and then the clinician can access the root canal system. The coronal access can be more conservative because of the benefits of the GentleWave Procedure.1,2 Next, all canals should be located in the access cavity, aided by the combination of the 2D periapical radiograph, the 3D CBCT volume, and direct visual observation through a dental operating microscope.

Canal lengths are verified as the clinician measures each canal from a reference point in the coronal aspect of the tooth to the apical constriction. This can also be done within the CBCT volume, due to the nature of its accuracy. An electronic apex locator can also be utilized to confirm the canal length.

The clinician can then prepare the canals to approximately 1.0 mm short of working length.

Next, the authors generally utilize no more than two to three variably tapered nickel-titanium rotary files to prepare each root canal to the same length, while maintaining much smaller diameters in the coronal aspect of the root canal system.

Initiation of the GentleWave Procedure requires the fabrication of an occlusal platform. Today this is accomplished utilizing SOUNDSEAL™ (Sonendo®, sonendo.com) and an included preformed plastic matrix. This platform allows the GentleWave Procedure Instrument to conform to the root canal access cavity. The GentleWave Procedure method of action requires an intact seal at the interface of the Procedure Instrument and the root canal coronal access cavity. After fabrication of the platform is completed, the GentleWave Procedure can begin. Currently, the procedure consists of approximately 8 minutes of continuously refreshed NaOCl, water, and EDTA at specific computer-controlled concentrations and intervals. During this time, the Procedure Instrument is manually held in place by the clinician. When the procedure is completed, the Procedure Instrument and the SOUNDSEAL platform are removed. Preparations for obturation of the root canal system can then be initiated, based on the clinician’s obturating method of choice. For example, the clinician may choose to obturate with warm gutta-percha in conjunction with a sealer. After obturation has been completed, the clinician can perform a coronal seal buildup procedure before removing the rubber dam. Finally, a postoperative 2D radiograph is acquired. Post-operative instructions are provided to the patient, including detailed information regarding the GentleWave Procedure that has been performed.

The appreciable visual difference when using the GentleWave Procedure is shown in Figure 1. Tooth No. 2 is the newer shape and tooth No. 3 is the older shape, which was still quite conservative. Tooth No. 2 showcases an example of closely maintaining the original anatomy. The GentleWave System enables the clinician to debride and disinfect the root canal system, resulting in a much smaller and more conservative shape.1,2 For example, the delicate distobuccal root canal anatomy in the apical one-third is exceptionally well-maintained.

Fig 1. The difference with the new technology is visually significant.
Fig 2. The delicate distobuccal right in the apical one-third is exceptionally well maintained.

REFERENCES
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**SONENDO.COM/RELATIONSHIP**

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\(^1\) Sigurdsson A et al. (2016) J Endod. 42:1040-48  
\(^3\) Vandrangi P et al. (2015) Oral Health 72-86  
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