The Expanded Role of Ultrasonics in Endodontic Treatment

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In July 1958, the *Journal of the Acoustical Society of America* described a new ultrasonic generator that had been designed for the specific needs of dentistry.[1] Since then, ultrasonic devices, such as the Cavitron (Dentsply, York, PA) have played a critical role in preventive, restorative and surgical procedures in almost every dental office in the world. A second milestone occurred in 1979, when Satelec (now part of the Acteon Group, Merignac Cedex, France) developed the first Piezo-Electric ultrasonic unit for dentistry. Just a little over a decade later, Dr. Gary Carr, an endodontist from San Diego, CA and founder of the Pacific Endodontic Research Foundation (PERF) and TDO (The Digital Office) had an idea that the piezo-electric ultrasonic would be ideal for a variety of endodontic applications, including surgical root end preparations. He would go on to develop this technique,[2] now in use by most endodontists, and invent several associated products and other techniques.

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In the early 1990s, the use of ultrasonics in endodontics greatly expanded, and many products are now in use by both endodontic specialists as well as an increasing number of general practitioners. This article will review the expanded role that ultrasonics have taken in root canal therapy, why piezo-electric technology is better suited to endodontics, current clinical uses and advances in both ultrasonic equipment and tips, and some of the science behind the technology.

THE PIEZO ADVANTAGE

Ultrasonic units used for operative and preventative procedures are generally divided into two categories, magneto restrictive (ie, Cavitron, Dentsply, York, PA) and Piezo Electric (ie, P5 Newtron, Acteon Merignac Cedex, France) (Fig 2, P5 Newtron, Acteon). Both of these types of ultrasonics are clinically proven to be effective for scaling and precise periodontal procedures. However, the Piezo-electric class of ultrasonics is better suited for endodontic use, therefore we will focus on this ultrasonic type

The word piezo comes from the Greek "piezein" which means to push, press or squeeze. The principle for this ultrasonic technology dates back to 1880 when Jacques and Pierre Curie discovered an unusual characteristic of certain crystalline minerals; when subjected to a mechanical force, the crystals became electrically polarized. The opposite also proved to be true; if one of these voltage-generating crystals was exposed to an electric field it lengthened or shortened according to the polarity of the field, and in proportion to the strength of the field. When this principle is applied to ultrasonics, electrical current produces a wave in the crystals (ie, series of ceramic discs or quartz plates inside the handpiece of the ultrasonic), (Fig 1) which are transferred to the ultrasonic tip. This creates a linear tip motion which is ideal for many endodontic procedures. The handpiece in this process does not generate excessive heat, so any water required is simply to cool the tooth and tip. Accordingly, if water is required at all, (depending on the procedure), a very light aerosol is all that is required, enhancing vision and patient comfort. As we review some of the applications of the Piezo-electric ultrasonic and the accompanying variety of tips, some of the advantages of these inherent features of Piezo units become obvious.

FIGURE 1—Satelec Handpiece Inside.

FIGURE 2—P5 Newtron.

FIGURE 3—P5XS Newtron XS.

FIGURE 4—LED Handpiece.

PIEZO ELECTRIC ULTRASONIC EQUIPMENT: NUANCES AND NEW FEATURES

Since the introduction of the first piezo-electric ultrasonic unit by Satelec in the late 1970s, there has been a steady improvement in the technology, functionality, ergonomics and appearance of the machines. The most important feature of any ultrasonic unit is how it "drives" the tip and adapts to a variety of tip designs and intended functions, as well as the often unpredictable clinical conditions. "The mechanism of ultrasonics is very different than other instruments",[3] such as a high speed handpiece. As Dr. David Clark (Tacoma, WA) has noted, it is somewhat "counter-intuitive", that increasing hand pressure or power settings does not necessarily increase cutting or vibrating efficiency. In many cases, it decreases efficiency. There are two variables of ultrasonic tip vibration; the frequency (number of vibrations per second) and power or intensity (usually operator controlled). The power function does not increase the frequency, it simply increases the back and forth range or amplitude of the tip. The latest advances in Piezo "drive" technology are evident in the Newtron™ line of ultraonics (Acteon, France / Clinical Research Dental, London, ON) (Figs. 2, 3). The module which controls each unit features three quite advanced functions.

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The unit operates in a frequency range of 28 kHz - 36 kHz, but every tip is slightly different, and requires its own ideal frequency. The Newtron module constantly monitors the weight and dimension of each tip and adjusts it accordingly in real time.

FIGURE 5—POV Led.

FIGURE 6—Irrigation at tip.

FIGURE 7—P Max Newtron XS.

FIGURE 8—Stropko Irrigator.

FIGURE 9—Ultradent Tips for Stropko.

FIGURE 9B—Ultradent endo eze tips.

With most ultrasonic units, the control unit pushes the tip to the farthest extent of its amplitude; the return is simply recoil action. The Newtron module controls both the push and pull of the tip resulting in even more precise tip control. The more tip control, the less likely the operator will break the ultrasonic tip.

While it is also true that Ultrasonic tips are usually more effective when they are allowed to "dance" on the tooth structure as opposed to being pushed by hand, the Newtron technology will adjust the power intelligently according to the load that it encounters in use, similar to torque control in electric endo motors.

WATER, AIR AND LIGHT

Many other features are offered by a variety of manufacturers. Optional fiber optic or LED handpieces (i.e., optional on the Varios by NSK and the Satelec Newtron models) (Fig 4) enhance visibility, but may be an unnecessary expense if the operator is using a high power LED headlight (Fig 5) or a microscope. Intense light, good magnification through loupes or a microscope, and a reliable ultrasonic are a must if you are treating molar endodontics. Water has been historically intrinsic to ultrasonic use, as it is necessary in magneto restrictive units to cool the handpiece, as well as the tooth surface and the tip. Piezo electric use still calls for water use routinely in perio and hygiene procedures, but for many endodontic applications water is optional. For example, in procedures later described, such as access refinement, or accessing calcified canals, much dentinal dust is created. This, mixed with water, can become a slurry that might clog the ultrasonic instrument, and will certainly obscure ones vision. However, there are advantages to intermittent water use. For example, when using an ultrasonic tip to remove a metal post by vibrating it, the heat generated can cause thermal injury to teeth and their supporting structures. In reporting on this, Gluskin et al recommended that when using ultrasonics for post removal, one should "Use devices that allow water to reach the working end of the ultrasonic tip to provide maximum cooling effect."[4] Additionally, intermittent use of water in access refinement,

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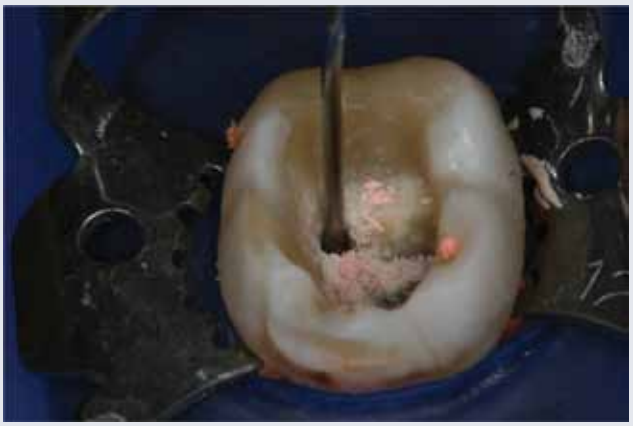

FIGURE 10—Stropko USE A.

FIGURE 11—Stropko USE B.

FIGURE 12A—Entering Calcified canal maxillary molar A.

FIGURE 12B—Entering Calcified canal maxillary molar B.

produces a clean surface and can reveal the dentinal roadmap, differentiating the pulp chamber floor from secondary dentin, which is necessary to begin the cleaning and shaping process effectively. In light of the advantages to occasional water use, ultrasonic tips with built in water ports are preferred over tips without.(Fig 6) The availability of air during ultrasonic use is also necessary. It also can act as a coolant, and a constant stream of well directed air can help maintain clear visibility, blowing away dentinal dust and debris. A recent model, the PMax Newtron XS by Satelec (Fig 7) , has an air feature that requires being hooked up to your office compressed air. This allows filtered air to be delivered through the tip port the same way water is delivered. This is a premium feature, and comes at a premium price. Alternatively, the use of a Stropko irrigator (Clinical research Dental, London, On) (Figs. 8-11), adapted to your air water syringe, allows your assistant to direct a very fine stream of air to the operative field.

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FINDING AND ACCESSING CALCIFIED CANALS; ACCESS ENHANCEMENT

"Tooth retention has increased significantly in older adults, and dentists are now challenged by the need to preserve critical teeth".[5] Among the challenges of endodontic therapy are calcified canals, pulp stones, and difficult to locate canals such as the MB2.[6,7] (Fig 12 a, b) The literature indicates that second mesial buccal canals in maxilliary molars exist most of the time. In one clinical study by Dr. John Stropko, which examined 1732 conventionally treated maxillary molars, " as the operator became more experienced, scheduled sufficient clinical time, routinely employed the dental operating microscope, and used specific instruments adapted for microendodontics, the MB2 canals were located in 93.0% of first molars and 60.4% in sec-

FIGURE 13—BL tips set.

FIGURE 13A

FIGURE 13B

FIGURE 13C

ond molars.[8] Note the operative concepts in this quote: Experience, adequate time, good magnification and specific instruments. For general dentists and specialists, the ultrasonic is an invaluable tool to gain entry into calcified canals, provided it is accompanied by the proper tip, good magnification and adequate light.[9,10] It is a less invasive tool than a high speed handpiece, the operator can always see the ultrasonic tip, unlike the inability to see around the head of a handpiece. Dr. Stephen Buchanan summarizes; "Any clinician who performs molar endodontics without ultrasonics is working too hard, is experiencing more anxiety than is necessary, and is most likely not finding MB2 canals in more than 40% of their maxillary molar cases".[11]

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A variety of different ultrasonic tips and tip surfaces are available on the market, including uncoated stainless steel, zirconium nitride coated and diamond coated tips. While numerous studies indicate that diamond coated tips have the best cutting efficiency,[12] sometimes this is short lived as during operation diamond particles can fall out or wear down quickly reducing cutting efficiency. New to the market are the BL series of tips (Fig 13) (B&L Biotech/Clinical Research Dental, London, ON) which feature micro-projections (small raised bumps) on the surface of the tip, which very effectively engage the tooth surface. The cutting surface lasts considerably longer than other coated tips, and because there is no diamond coating process, are considerably less costly. This set contains four tips which are ideal for canal orifice location and expansion, locating MB 2s, planing down pulp stones and chamber floor irregularities, and refining access preparations (Fig 13 a, b, c). Whichever tips are chosen, it is important to obtain the right instrument for the right job. For instance, where the canal orifice location and angle is known, a short active tip, which comes to a

FIGURE 14A—A longer and thinner tip with a cutting end.

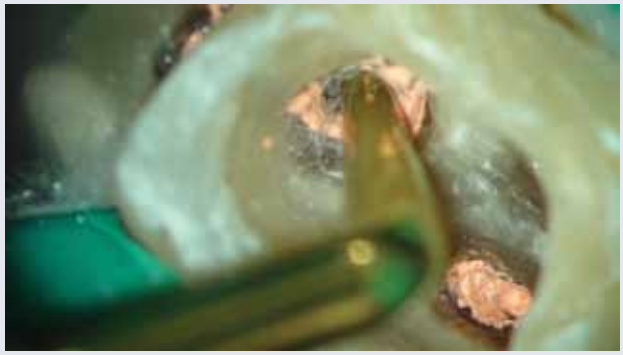

FIGURE 14B

FIGURE 14C

FIGURE 14D

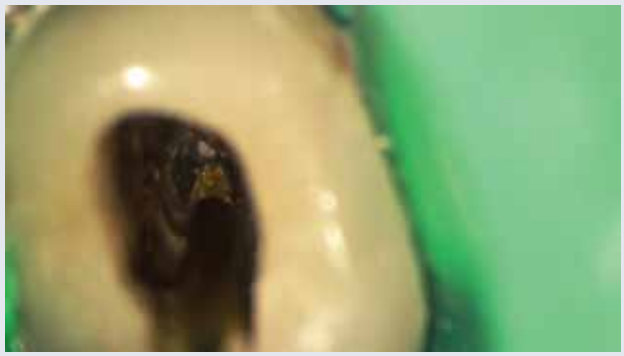

FIGURE 14E

FIGURE 15A—IrriSafe tip.

FIGURE 15B—Irrisafe in action.

FIGURE 15C—Irrisafe acoustic streaming.

point is most effective for heavily calcified canals. However, the use of a rounded tip, especially when locating a canal orifice or troughing between two canal orifices,is safer and will prevent perforation. A tapered cylindrical shaped tip is also effective for removal of secondary dentin or pulp stones on canal walls and the pulp chamber floor, as well as removal of calcified pulp horns to enhance access visibility. A disc shaped, end-cutting tip is useful as a chamber floor sander. A longer and thinner tip with a cutting end is also useful for dentin and pulp stone removal further down the canal (Fig 14), and may also be used for coronal shaping in ovoid shaped canals.[13] In all cases the linear tip movement of piezo-electric tips is ideal for the above applications. Remember, regarding power settings for these procedures, LESS IS MORE. Let the tip dance on the surface and do its job, at low to medium power. Resist the urge to crank it up, you do not need an "eleven." (From the movie This Is Spinal Tap)

FIGURE 16A—31 ga. NaviTip Side Port Irrigating Needle.

FIGURE 16B—31ga NaviTip clinical.

ENHANCING ENDODONTIC IRRIGATION

Advancements in canal shaping instruments and techniques has led to a much larger emphasis on root canal irrigation protocols. High volume and frequent exchange of sodium hypochlorite throughout the cleaning and shaping procedure has virtually become the standard of care. However, complete removal of canal organic and inorganic debris, especially from the apical third and fins and lateral canals continues to be a challenge. Ultrasonic stimulation of the irrigants in the canals has been clinically proven as an effective adjunct to mechanically cleaning and shaping the roots.[14-16] Ultrasonic activation of irrigants produces at least two positive effects: Cavitation; the formation of thousands of tiny bubbles which implode, removing biofilm and acoustic streaming which has been shown to produce shear forces that will dislodge debris in instrumented canals. An excellent instrument to effect this type of passive irrigation stimulation is the Irrisafe file (Acteon, France/ Clinical Research Dental. London, On)) (Fig 15a, b. c). It has a long, thin, parallel tip with flutes such as is found on a K file. The flutes are designed to effect acoustic streaming, and are rounded so they will not engage the dentin causing breakage or canal transportation. To use these tips effectively, the canal is filled with sodium hypochlorite (A very safe and effective needle for introducing NaOCI to the apical third is the 31 ga. Navitip (Ultradent, South Jordan, UT) , which has 2 side ports offset to each other, and is capped at the end (Fig 16A and B). The Irrisafe tip is then introduced into the apical third, at least 1mm short of working length. The tip is then activated at medium power for one minute, with the irrigant subsequently evacuated by a Luer Vac Adapter (Ultradent, South Jordan, UT) (Fig 17) This is a well accepted method of enhancing success in irrigation and canal disinfection.[17,18]

Metal post removal is an arduous, time-consuming task that can be greatly assisted with the use of the correct ultrasonic tip

REMOVAL OF INTRACANAL OBSTRUCTIONS

There will be a certain number of cases that will present that will require re-treatment of a previously restored, endodontically treated tooth. This will often require disassembly of the restoration, perhaps including removal of a metal post, a silver point, gutta percha, obturation carriers, etc. There is also the possibility of instrument separation during root canal therapy. The Piezo-electric ultrasonic is also an invaluable tool for these procedures. It should be noted that often the endodontist is best suited to handle these procedures, having been well educated on the rationale for re-treatment, possessing unique experience in retreating many cases, and having ALL the instruments and tools necessary to deal with

FIGURE 17—luer vacuum adapters.

FIGURE 18—Jetip Surgical.
(Courtesy Dr. Marga Ree, Netherlands)

the most difficult, unusual and unexpected conditions.[19]

Metal post removal is an arduous, time-consuming task that can be greatly assisted with the use of the correct ultrasonic tip. A tip that will engage or contact and vibrate the post directly can break up the post cement rendering it loose enough to be removed. Other times, this must be followed up with a long more slender tip which is used to trough around the post, gradually loosening or dislodging it. In these cases, water is necessary to keep the tooth cool to avoid the earlier stated "thermal injury". The same strategy can be employed to remove other obstructions, including silver points, obturation carriers, pins, and broken files. Choice of the proper tip is very important. For troughing around obstructions in the canal, here are some good tips to keep in mind:

- Try to use the largest diameter and shortest length possible (analogous to a crown down approach to cleaning and shaping), depending on where the top of the obstruction is located. DO NOT pick a one-size-fits -all tip!

- ALWAYS use low power when using a tip in a canal. With a tight fit, a lower amplitude is actually better.

- When removing a threaded post or an endodontic file, using a counterclockwise motion might facilitate removal

- If you cannot see it, you probably will not get it.

It cannot be overstated that excellent visibility, good magnification, and proper illumination are ALL necessary for success in these ultrasonic uses. Experience and good case selection are also of paramount importance.

There are an ever expanding number of restorative procedures well suited for ultrasonics, and more advances in oral surgical applications are sure to come

OTHER USES PRESENT AND FUTURE

Other current uses for ultrasonics in endodontics include removing gutta percha, condensing gutta percha, vibrating perforation repair material such as MTA (Mineral Trioxide Aggregate) into position, and of course, root end surgical preparations (Fig 18), which is the original intended use of ultrasonics. There are an ever expanding number of restorative procedures well suited for ultrasonics, and more advances in oral surgical applications are sure to come.

The challenges are present in treating teeth in an aging and more sophisticated population. Thomas Edison said "there's a way to do it better - find it". The use of ultrasonics in endodontics may be one way of doing just that. OH

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Oral Health welcomes this original article.

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Figures 14a-e, are courtesy Dr. Yoshi Terauchi, Tokyo, Japan¶

¶Figures 12 a and 12b, are courtesy of Dr. Helmut Walsch, Munich Germany¶