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New ways to learn

When it comes to dentistry in general, and the specialty of endodontics in particular, there is always a lot to learn. That's why dental meetings like the AAE Annual Session are so important. The dental literature is valuable as well — especially a C.E. magazine like the one you are holding now (more on that in a moment).

In this issue of roots, you can find articles on new ways to learn. Namely, there are new 3-D training replicas, available from Dr. L. Stephen Buchanan and his team at Dental Education Laboratories. (These new tooth models, I'm told, are a delight to work with.) There's an article about a three-day course available at the Las Vegas Institute for Advanced Dental Studies. This issue also contains a report by Dr. Gary Glassman on endodontic irrigation. He reveals the results of research on various irrigation systems and their efficacy.

By reading the article by Dr. Glassman, then taking a short online quiz about his article at www.DTStudyClub.com, you will gain one ADA CERP-certified C.E. credit. Keep in mind that because roots is a quarterly magazine, you can actually chisel four C.E. credits per year out of your already busy life without the lost revenue and time away from your practice.

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I know that taking time away from your practice to pursue C.E. credits is costly in terms of lost revenue and time, and that is another reason roots is such a valuable publication. I hope you will enjoy this issue and that you will take advantage of the C.E. opportunity.

For those of you attending the AAE Annual Session this spring in Washington, D.C., be sure to say hello in person. I’ll also be at the spring CDA Presents the Art and Science of Dentistry meeting in Anaheim, Calif. As always, I welcome your comments and feedback.

Sincerely,

Fred Weinstein, DMD, MRCD(C), FICD, FACD
Editor in Chief
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The image is of a TrueTooth™ training replica. Designed by Dr. L. Stephen Buchanan and re-created by a 3-D printer, these are authentic replicas of the internal and external anatomy of CT-scanned extracted teeth, with bleach-dissolvable material in the root canal passageways. TrueTooth training replicas are available exclusively from www.DELendo.com and are patent pending. (Image/Provided by L. Stephen Buchanan, DDS, FICD, FACD)
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Endodontic irrigants and irrigant delivery systems

Author: Gary Glassman, DDS, FRCD(C)

Endodontic treatment is a predictable procedure with high success rates. Success depends on a number of factors, including appropriate instrumentation, successful irrigation and decontamination of the root-canal space to the apices and in areas such as isthmuses. These steps must be followed by complete obturation of the root canals, and placement of a coronal seal, prior to restorative treatment.

Several irrigants and irrigant delivery systems are available, all of which behave differently and have relative advantages and disadvantages. Common root-canal irrigants include sodium hypochlorite (NaOCl), chlorhexidine gluconate, alcohol, hydrogen peroxide and ethylenediaminetetraacetic acid (EDTA). In selecting an irrigant and technique, consideration must be given to their efficacy and safety.

With the introduction of modern techniques, success rates of up to 98 percent are being achieved. The ultimate goal of endodontic treatment per se is the prevention or treatment of apical periodontitis, such that there is complete healing and an absence of infection, while the overall long-term goal is the placement of a definitive, clinically successful restoration and preservation of the tooth. For these to be achieved, appropriate instrumentation, irrigation, decontamination and root-canal obturation must occur, as well as attainment of a coronal seal.

There is evidence that apical periodontitis is a biofilm-induced disease. A biofilm is an aggregate...
of microorganisms in which cells adhere to each other and/or to a surface. These adherent cells are frequently embedded within a self-produced matrix of extracellular polymeric substance. The presence of microorganisms embedded in a biofilm and growing in the root-canal system is a key factor for the development of periapical lesions.9–13 Additionally, the root-canal system has a complex anatomy that consists of arborisations, isthmuses and cul-de-sacs that harbor organic tissue and bacterial contaminants (Figs. 1a,b).8

The challenge for successful endodontic treatment has always been the removal of vital and necrotic remnants of pulp tissue, debris generated during instrumentation, the dentin smear layer, microorganisms, and micro-toxins from the root-canal system.9

Even with the use of rotary instrumentation, the nickel-titanium instruments currently available only act on the central body of the root canal, resulting in a reliance on irrigation to clean beyond what may be achieved by these instruments.12 In addition, Enterococcus faecalis and Actinomyces — which are both implicated in endodontic infections and in endodontic failure — penetrate deep into dentinal tubules, making their removal through mechanical instrumentation impossible.11,12

Finally, E. faecalis commonly expresses multidrug resistance,13–15 complicating treatment.

Therefore, a suitable irrigant and irrigant delivery system are essential for efficient irrigation and the success of endodontic treatment.16 Root-canal irrigants must not only be effective for dissolution of the organic of the dental pulp, but also effectively eliminate bacterial contamination and remove the smear layer — the organic and inorganic layer that is created on the wall of the root canal during instrumentation. The ability to deliver irrigants to the root-canal terminus in a safe manner without causing harm to the patient is as important as the efficacy of those irrigants.

Over the years, many irrigating agents have been tried in order to achieve tissue dissolution and bacterial decontamination. The desired attributes of a root-canal irrigant include the ability to dissolve necrotic and pulp tissue, bacterial decontamination and a broad antimicrobial spectrum, the ability to enter deep into the dentinal tubules, biocompatibility and lack of toxicity, the ability to dissolve inorganic material and remove the smear layer, ease of use, and moderate cost.

As mentioned above, root-canal irrigants currently in use include hydrogen peroxide, NaOCl, EDTA, alcohol and chlorhexidine gluconate. Chlorhexidine gluconate offers a wide antimicrobial spectrum, the main bacteria associated with endodontic infections (E. faecalis and A. israelii) are sensitive to it, and it is biocompatible, with no tissue toxicity to the periapical or surrounding tissue.17 Chlorhexidine gluconate, however, lacks the ability to dissolve necrotic tissue, which limits its usefulness. Hydrogen peroxide as a canal irrigant helps to remove debris by the physical act of irrigation, as well as through effervescing of the solution. However, while an effective anti-bacterial irrigant, hydrogen peroxide does not dissolve necrotic intra-canal tissue and exhibits toxicity to the surrounding tissue.

Cases of tissue damage and facial nerve damage have been reported following use of hydrogen peroxide as a root-canal irrigant.18 Alcohol-based canal irrigants have antimicrobial activity too, but they do not dissolve necrotic tissue.

The irrigant that satisfies most of the requirements for a root-canal irrigant is NaOCl.19,20 It has the unique ability to dissolve necrotic tissue and the organic components of the smear layer.19,21,22 It also kills sessile endodontic pathogens organized in a biofilm.23,24 There is no other root-canal irrigant that can meet all these requirements, even with the use of methods such as lowering the pH,25–27 increasing the temperature28–32 or adding surfactants to increase the wetting efficacy of the irrigant.33,34 However, although NaOCl appears to be the most desirable single endodontic irrigant, it cannot dissolve inorganic dentine particles and thus cannot prevent the formation of a smear layer during instrumentation.35

Calcifications hindering mechanical preparation are frequently encountered in the root-canal system, further complicating treatment. Demineralizing agents such as EDTA have therefore been recommended as adjuvants in root-canal therapy.20,36 Thus, in contemporary endodontic practice, dual irrigants such as NaOCl with EDTA are often used as initial and final rinses to circumvent the shortcomings of a single irrigant.37–39 These irrigants must be brought into direct contact with the entire canal-wall surfaces for effective action,39,40 particularly in the apical portions of small root canals.9

The combination of NaOCl and EDTA has been used worldwide for antisepsis of root-canal systems. The concentration of NaOCl used for root-canal irrigation ranges from 2.5 to 6 percent, depending on the country and local regulations; it has been shown, however, that tissue hydrolyzation is greater at the higher end of this range, as demonstrated in a study by Hand et al. comparing 2.5 and 5.25 percent NaOCl.

The higher concentration may also favor superior microbial outcomes.41 NaOCl has a broad antimicrobial spectrum,25 including but not limited to E. faecalis. NaOCl is superior among irrigating agents...
that dissolve organic matter. EDTA is a chelating agent that aids in smear layer removal and increases dentine permeability, which will allow further irrigation with NaOCl to penetrate deep into the dentinal tubules.

General safety precautions

Regardless of which irrigant and irrigation system is employed, and particularly if an irrigant with tissue toxicity is used, there are several general precautions that must be followed. A rubber dam must be used and a good seal obtained to ensure that no irrigant can spill from the pulp chamber into the oral cavity. If deep caries or a fracture is present adjacent to the rubber dam on the tooth being isolated, a temporary sealing material must be used prior to performing the procedure to ensure a good rubber dam seal. It is also important to protect the patient’s eyes with safety glasses and protect clothing from irrigant splatter or spill.

It is very important to note that while NaOCl has unique properties that satisfy most requirements for a root-canal irrigant, it also exhibits tissue toxicity that can result in damage to the adjacent tissue, including nerve damage should NaOCl incidents occur during canal irrigation. Furthermore, Salzgeber reported in the 1970s that apical extrusion of an endodontic irrigant routinely occurred in vivo. This highlights the importance of using devices and techniques that minimize or prevent this. NaOCl incidents are discussed later in this article.

Irrigant delivery systems

Root-canal irrigation systems can be divided into two categories: manual agitation techniques and machine-assisted agitation techniques. Manual irrigation includes positive-pressure irrigation, which is commonly performed with a syringe and a sidevented needle. Machine-assisted irrigation techniques include sonics and ultrasonics, as well as newer systems such as the EndoVac (SybronEndo), which delivers apical negative-pressure irrigation, the plastic rotary F File (Plastic Endo), the Rinsendo (Air Techniques), and the EndoActivator (DENTSPLY Tulsa Dental Specialties).

Two important factors that should be considered during the process of irrigation are whether the irrigation system can deliver the irrigant to the whole extent of the root-canal system, particularly to the apical third, and whether the irrigant is capable of debriding areas that could not be reached with mechanical instrumentation, such as lateral canals and isthmuses. When evaluating irrigation of the apical third, the phenomenon of apical vapor lock should be considered.

Apical vapor lock

Because roots are surrounded by the periodontium, and unless the root-canal foramen is open, the root canal behaves like a closed-ended channel. This produces an apical vapor lock that resists displacement during instrumentation and final irrigation, thus preventing the flow of irrigant into the apical region and adequate debridement of the root-canal system.

Apical vapor lock also results in gas entrapment at the apical third. During irrigation, NaOCl reacts with organic tissue in the root-canal system, and the resulting hydrolysis liberates abundant quantities of ammonia and carbon dioxide. This gaseous mixture is trapped in the apical region and quickly forms a column of gas through which further fluid penetration is impossible. Extension of instruments into this vapor lock does not reduce or remove the gas bubble, just as it does not enable adequate flow of irrigant.

The phenomenon of apical vapor lock has been confirmed in studies in which roots were embedded in a polyvinylsiloxane impression material to restrict fluid flow through the apical foramen, simulating a closed-ended channel. The result in these studies was incomplete debridement of the apical part of the canal walls with the use of a positive-pressure syringe delivery technique.

Micro-CT scanning and histological tests conducted by Tay et al. have also confirmed the presence of apical vapor lock. In fact, studies conducted without ensuring a closed-ended channel cannot be regarded as conclusive on the efficacy of irrigants and the irrigant system. The apical vapor lock may also explain why in a number of studies investigators were unable to demonstrate a clean apical third in sealed root canals.

In a paper published in 1983 based on research, Chow determined that traditional positive-pressure irrigation had virtually no effect apical to the orifice of the irrigation needle in a closed root-canal system. Fluid exchange and debris displacement were minimal. Equally important to his primary findings, Chow set forth an infallible paradigm for endodontic irrigation: "For the solution to be mechanically effective in removing all the particles, it has to: (a) reach the apex; (b) create a current (force); and (c) carry the particles away." The apical vapor lock and consideration for the patient’s safety have always prevented the thorough cleaning of the apical 3 mm. It is critically important to determine which irrigation system will effectively irrigate the apical third, as well as isthmuses and lateral canals, and in a safe manner that prevents the extrusion of irrigant.
Manual agitation techniques

By far the most common and conventional set of irrigation techniques, manual irrigation involves dispensing of an irrigant into a canal through needles/cannulae of variable gauges, either passively or with agitation by moving the needle up and down the canal space without binding it on the canal walls. This allows good control of needle depth and the volume of irrigant that is flushed through the canal.9,63 However, the closer the needle tip is positioned to the apical tissue, the greater the chance of apical extrusion of the irrigant.67, 68 This must be avoided; were NaOCl to extrude past the apex, a catastrophic accident could occur.69

Manual-dynamic irrigation

Manual-dynamic irrigation involves gently moving a well-fitting gutta-percha master cone up and down in short 2- to 3-mm strokes within an instrumented canal, thereby producing a hydrodynamic effect and significant irrigant exchange.70 Recent studies have shown that this irrigation technique is significantly more effective than automated-dynamic irrigation and static irrigation.9,71,72

Machine-assisted agitation systems

Sonic irrigation

Sonic activation has been shown to be an effective method for disinfecting root canals, operating at frequencies of 1–6k Hz.73, 74 There are several sonic irrigation devices on the market. The Vibringe allows delivery and sonic activation of the irrigating solution in one step. It employs a two-piece syringe with a rechargeable battery. The irrigant is sonically activated, as is the needle that attaches to the syringe. The EndoActivator is a more recently introduced sonically driven canal irrigation system.80,81 It consists of a portable handpiece and three types of disposable polymer tips of different sizes. The EndoActivator has been reported to effectively clean debris from lateral canals, remove the smear layer and dislodge clumps of biofilm within the curved canals of molar teeth.9

Ultrasonics

Ultrasonic energy produces higher frequencies than sonic energy but low amplitudes, oscillating at frequencies of 25–30 kHz.9,29 Two types of ultrasonic irrigation are available. The first type is simultaneous ultrasonic instrumentation and irrigation, and the second type is referred to as passive ultrasonic irrigation operating without simultaneous irrigation (PUI).

The literature indicates that it is more advantageous to apply ultrasounds after completion of canal preparation rather than as an alternative to conventional instrumentation.9,20,77 PUI irrigation allows energy to be transmitted from an oscillating file or smooth wire to the irrigant in the root canal by means of ultrasonic waves.9 There is consensus that PUI is more effective than syringe needle irrigation at removing pulpal tissue remnants and dentine debris,78–80 This may be due to the much higher velocity and volume of irrigant flow that are created in the canal during ultrasonic irrigation.80 PUI has been shown to remove the smear layer; there is a large body of evidence with different concentrations of NaOCl.80–84 In addition, numerous investigations have demonstrated that the use of PUI after hand or rotary instrumentation results in a significant reduction in the number of bacteria,9,85–87 or achieves significantly better results than syringe needle irrigation.9,84,88,89

Studies have demonstrated that effective delivery of irrigants to the apical third can be enhanced by using ultrasonic and sonic devices that demonstrate acoustic micro-streaming and cavitation.79,81,90,91 Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the ultrasound energy creating mechanical pressure changes within the tissue. Cavitation is defined as the formation and collapse of gas and vapor-filled bubbles or cavities in a fluid.

The Apical Vapor Lock theory, proven in vitro by Tay, has been clinically demonstrated92 to also include the middle third by Vera: “The mixture of gases is originally trapped in the apical third, but then it might grow quickly by the nucleation of the smaller bubbles, forming a gas column that might not only impede penetration of the irrigant into the apical third but also push it coronally after it has been delivered into the canal.” However, more recently Munoz93 demonstrated that both passive ultrasonic irrigation
(PUI) and EndoVac are more effective than the conventional endodontic needle in delivering irrigant to WL of root canals."

This raises the efficacy question. Two recently published studies examined this issue with both systems by testing their ability to eliminate microorganisms during clinical treatment from infected root canal systems. Paiva fund that after a supplementary irrigation procedure using PUI with NaOCl that 23 percent of the samples produced positive cultures. Cohenca’s study examining the clinical efficacy of the EndoVac fund no microbial growth either after post instrumentation irrigation or at the one week obturation appointment.

When questioning these diverse results, one must remember that microbial hydrolysis via NaOCl is an equilibrium reaction. Hand demonstrated that a 50 percent reduction of NaOCl concentration resulted in a 300 percent reduction in dissolution activity. Accordingly, one must consider both the delivery of the irrigant to full working length, via PUI or apical negative pressure and the total volume of NaOCl exchanged. The volume of an instrumented root canal 19 mm long shaped to a #35 with a 6 percent instrument equals 0.014 cc. Paiva described placement of NaOCl via a NaviTip (Ultradent) at WL — 4 mm during instrumentation and discussed using PUI with #15 K file at WL — 1 mm. Prior to PUI, 2 ml of NaOCl was injected into the canal; however, this could not have filled the apical 4 mm95 due to the apical vapor lock. According to Munoz, the canal was most likely immediately filled with ultrasonically activated NaOCl for one minute, but as just described — only about 0.014 cc would have been effectively available for this exchange and activation. In contrast, the Apical Negative Pressure protocol described by Cohenca et al. approximately 2 ml of NaOCl actively passes through the complete WL for one92 minute.92 The difference in volumetric exchange equals 2(0.014 = 14, 200 percent and likely explains the disinfection differential.

**The plastic rotary F File**

Although sonic or ultrasonic instrumentation is more effective at removing residual canal debris than rotary endodontic files are, and irrigation solutions are often unable to remove this during endodontic treatment, many clinicians still do not incorporate it into their endodontic instrument armamentarium.

The common reasons given for not using sonic or ultrasonic filing are that it can be time-consuming to set up, an unwillingness to incur the cost of the equipment, and lack of awareness of the benefits of this final instrumentation step in endodontic treatment.

It is for these reasons that an endodontic polymer-based rotary finishing file was developed. This new, single-use, plastic rotary file has a unique file design with a diamond abrasive embedded into a non-toxic polymer. The F File will remove dentinal wall debris and agitate the NaOCl without enlarging the canal further.

**Pressure-alternation devices**

Rinsendo irrigates the canal by using pressure-suction technology. Its components are a handpiece, a cannula with a 7 mm exit aperture, and a syringe carrying irrigant. The handpiece is powered by a dental air compressor and has an irrigation speed of 6.2 ml per minute. Research has shown that it has promising results in cleaning the root-canal system, but more research is required to provide scientific evidence of its efficacy. Periapical extrusion of irrigant has been reported with this device.

**The EndoVac apical negative-pressure system**

The EndoVac apical negative-pressure irrigation system has three components: the Master Delivery Tip, MacroCannula and MicroCannula. The Master Delivery Tip simultaneously delivers and evacuates the irrigant (Fig. 2). The MacroCannula is used to suction irrigant from the chamber to the coronal and middle segments of the canal. The MacroCannula or MicroCannula is connected via tubing to the high-speed suction of a dental unit. The Master Delivery Tip is connected to a syringe of irrigant and the evacuation hood is connected via tubing to the high-speed suction of a dental unit. The plastic MacroCannula has an open end of ISO size 0.55 mm in diameter with a 0.02 taper and is attached to a handpiece for gross, initial flushing of the coronal and mid-length parts of the root canal. The MicroCannula contains 12 microscopic holes and is capable of evacuating debris to full working length.

The ISO size 0.32 mm diameter stainless-steel MicroCannula has four sets of three laser-cut, laterally positioned offset holes adjacent to its closed end, 100 μ in diameter and spaced 100 μ apart. This is attached to a finger piece for irrigation of the apical part of the canal when it is positioned at working length. The MicroCannula can be used in canals that are enlarged with endodontic files to ISO size 35.04 or larger.

During irrigation, the Master Delivery Tip delivers irrigant to the pulp chamber and siphons off the excess irrigant to prevent overflow. Both the Macro-Cannula and MicroCannula exert negative pressure that pulls fresh irrigant from the chamber, down the canal to the tip of the cannula, into the cannula, and out through the suction hose. Thus, a constant flow of fresh irrigant is delivered by negative pressure to working length. A recent study showed that the volume of irrigant delivered was significantly higher
than the volume delivered by conventional syringe needle irrigation within the same period, and resulted in significantly more debris removal at 1 mm from working length than did needle irrigation.

During conventional root-canal irrigation, clinicians must be careful when determining how far an irrigation needle is placed into the canal. Recommendations for avoiding NaOCl incidents include not binding the needle in the canal, not placing the needle close to working length, and using a gentle flow rate when using positive-pressure irrigation. With the EndoVac, in contrast, irrigant is pulled into the canal at working length and removed by negative pressure. Apical negative pressure has been shown to enable irrigants to reach the apical third and help overcome apical vapor lock. In addition, with respect to isthmus cleaning, although it is not possible to reach and clean the isthmus area with instruments, it is not impossible to reach and thoroughly clean these areas with NaOCl when the method of irrigation is safe and efficacious. In studies comparing the EndoActivator, passive ultrasonic, the F File, the manual-dynamic Maxi-Probe (DENTSPLY Rinn), the Pressure Ultrasonic and the EndoVac, only the EndoVac was capable of cleaning 100 percent of the isthmus area.

Apart from being able to avoid air entrapment, the EndoVac system is also advantageous in its ability to deliver irrigants safely to working length without causing their undue extrusion into the periapex, thereby avoiding NaOCl incidents. It is important to note that it is possible to create positive pressure in the pulp canal if the Master Delivery Tip is misused, which would create the risk of a NaOCl incident. The manufacturer’s instructions must be followed for correct use of the Master Delivery Tip.

Sodium hypochlorite incidents

Although a devastating endodontic NaOCl incident is rare, the cytotoxic effects of NaOCl on vital tissue are well established. The associated sequelae of NaOCl extrusion have been reported to include life-threatening airway obstructions, facial disfigurement requiring multiple corrective surgical procedures, permanent paraesthesia with loss of facial muscle control, and — the least significant consequence — tooth loss.

Although the exact etiology of the NaOCl incident is still uncertain, based on the evidence from actual incidents and the location of the associated tissue trauma, it would appear that an intravenous injection may be the cause. The patient shown in Figure 3 demonstrates a widespread area of tissue trauma that is consistent with the characteristics of NaOCl incident trauma reported by Pashley.

This extensive trauma, and particularly involving the pattern of ecchymosis around the eye, could have occurred only if the NaOCl had been introduced intravenously to a vein close to the root apex through which extrusion of the irrigant occurred and the irrigant then found its way into the venous complex. This would require positive pressure apically that exceeded venous pressure (10mg of Hg). In one in-vitro study, which used a positive-pressure needle irrigation technique to mimic clinical conditions and techniques, the apical pressure generated was found to be eight times higher than the normal venous pressure.

This does not imply that NaOCl can or should be excluded as an endodontic irrigant; in fact, its use is critical, as has been discussed in this article. What this does imply is that it must be delivered safely.

Safety first

In order to compare the safety of six current intra-canal irrigation delivery devices, an in-vitro test was conducted using the worst-case scenario of apical extrusion, with neutral atmospheric pressure and an open apex. The study concluded that the EndoVac did not extrude irrigant after deep intra-canal delivery and suctioning of the irrigant from the chamber to full working length, whereas other devices did. The EndoActivator extruded only a very small volume of irrigant, the clinical significance of which is not known. Mitchell and Baumgartner tested irrigant (NaOCl) extrusion from a root canal sealed with a permeable agarose gel. Significantly less extrusion occurred using the EndoVac system compared with positive-pressure needle irrigation. A well-controlled study by Gondim et al. found that patients experienced less postoperative pain, measured objectively and
subjectively, when apical negative-pressure irrigation was performed (EndoVac) than with apical positive-pressure irrigation.115

_Efficacy_

In vitro and in vivo studies have demonstrated greater removal of debris from the apical walls and a statistically cleaner result using apical negative pressure irrigation in closed root-canal systems with sealed apices. In an in vivo study of 22 teeth by Siu and Baumgartner, less debris remained at 1 mm from working length using apical negative pressure compared with use of traditional needle irrigation, while Shin et al. found in an in vitro study of 68 teeth comparing traditional needle irrigation with apical negative pressure that these methods both resulted in clean root canals, but that apical negative pressure resulted in less debris remaining at 1.5 and 3.5 mm from working length.46,104,116

When comparing root-canal debridement using manual dynamic agitation or the EndoVac for final irrigation in a closed system and an open system, it was found that the presence of a sealed apical foramen adversely affected debridement efficacy when manual-dynamic agitation was used, but did not adversely affect results when the EndoVac was used. Apical negative-pressure irrigation is an effective method to overcome the fluid-dynamic challenges inherent in closed root-canal systems.117

_Microbial control_

Hockett et al. tested the ability of apical negative pressure to remove a thick biofilm of E. Faecalis, finding that these specimens rendered negative cultures obtained within 48 hours, while those irrigated using traditional positive-pressure irrigation were positive at 48 hours.99

One study found that apical negative-pressure irrigation resulted in similar bacterial reduction to use of apical positive-pressure irrigation and a triple antibiotic in immature teeth.118 In a study comparing the use of apical positive-pressure irrigation and a triple antibiotic that has been utilized for pulpal regeneration/revascularisation in teeth with incompletely formed apices (Trimix = Cipro, Minocin, Flagyl) versus use of apical negative-pressure irrigation with NaOCl, it was found that the results were statistically equivalent for mineralized tissue formation and the repair process.119 Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discoloration and allergic reactions.120,121

_Conclusion_

Since the dawn of contemporary endodontics, dentists have been syringing NaOCl into the root canal space and then proceeding to place endodontic instruments down the canal in the belief that they were carrying the irrigant to the apical termination.

Biological, scanning electron microscopy, light microscopy and other studies have proven this belief to be in error. NaOCl reacts with organic material in the root canal and quickly forms micro-bubbles at the apical termination that coalesce into a single large apical vapor bubble with subsequent instrumentation. Because the apical vapor lock cannot be displaced via mechanical means, it prevents further NaOCl flow into the apical area.

The safest method yet discovered to provide fresh NaOCl safely to the apical terminus to eliminate the apical vapor lock is to evacuate it via apical negative pressure. This method has also been proven to be safe because it always draws irrigants to the source via suction — down the canal and simultaneously away from the apical tissue in abundant quantities.122

When the proper irrigating agents are delivered safely to the full extent of the root-canal terminus, thereby removing 100 percent of organic tissue and 100 percent of the microbial contaminants, success in endodontic treatment may be taken to levels never seen before._

Editorial note: A complete list of references is available from the publisher.

This article has been reprinted in part from G. Glassman, Safety and Efficacy Considerations in Endodontic Irrigation (PenWell, January 2011).

about the author

Dr. Gary Glassman graduated from the University of Toronto, Faculty of Dentistry in 1984. He graduated from the Endodontology Program at Temple University in 1987, where he received the Louis I. Grossman Study Club Award for academic and clinical proficiency in endodontics. The author of numerous publications, Glassman lectures globally on endodontics, is on staff at the University of Toronto, Faculty of Dentistry in the graduate department of endodontics, and adjunct professor of dentistry and director of endodontic programming for the University of Technology, Kingston, Jamaica. He is a fellow of the Royal College of Dentists of Canada, fellow of the American College of Dentists, and the endodontic editor for Oral Health Dental Journal. He maintains a private practice, Endodontic Specialists, in Toronto, Ontario, Canada. He can be reached at gary@rootcanals.ca.
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“I wish I would have attended LVI earlier in my career. I still have time to make a difference but this info is too valuable to not be used throughout an entire dental career.”
—Dr. Tim Stirneman Algonquin, IL

“Not only did I learn what I didn’t know about dentistry, I learned how to help my own long history of pain in the head and neck. Thanks for the missing link.”
—Dr. Paul Bell, Denver, CO

Upcoming 2014 DATES
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October 1-3 - LVI (Las Vegas)
December 10-12 - LVI (Las Vegas)

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We buy “New Tech” when we perceive that some part of our personal or professional lives could be managed more easily with this new tool. We bought billions of cordless and then wireless phones because we wanted to talk to anybody, any time, regardless of where we happened to be when the spirit moved us. And it was good. Beyond good was when Steve Jobs shoved computing power, endless content and the whole wide-world Internet through our mobile phones. Who knew?

That’s how I have experienced every one of my New Tech adventures. First I use it to imitate what we did before — i.e., replacing slide carousels with computers — only later to find creative possibilities never imagined. In my example, it was discovering the power that clinical video footage can bring to lectures.

In that transition, my first concern was how to fill a 10-by-30-foot screen with a single video projector, without the three side-by-side stacks of slide projectors we used before. After worrying that one to death, I realized that the greatest storytellers on earth — Hollywood, Bollywood, etc. — pitched their $100 million stories on a single screen — so why did I need three? After that small epiphany, I concentrated my efforts on how to do what they do, and now I can do much of what these masters of the entertainment universe do, in ultra-high-def, with just a laptop computer.

So has been my experience with 3-D printed tooth replicas. I went into stereolithography looking for a simpler method of teaching endodontic procedures, a way around the grossness — they are discarded body parts, after all — as well as the unpredictable nature of teaching RCT in the random anatomic forms found inside the extracted teeth that course attendees gather. What I encountered was much more profound than just having a training model that didn’t smell.

After about six months of experimentation, numerous experiments in polymer chemistry and a seemingly endless series of plugged-up print heads, we learned how to make clear TrueTooth® replicas that were radio-opaque with a pulp-colored medium inside each canal space that can be digested with sodium hypochlorite. TrueTooth procedural training replicas were born (Fig. 1).
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SEM of a dentin tubule cleaned with GentleWave™

VISIT SONENDO AT AAE BOOTH 823

© 2014. All rights reserved. The Sonendo device is not currently for sale in the U.S.
Here are the things I have learned about their use in the past year of teaching hands-on courses with them:

1) We can now, for the first time, teach RCT to dental students and dentists in an iterative manner, the same way astronauts are trained, by repetition. Previously, in extracted teeth, a student faced with an anatomic endo challenge only got a single chance to get it right. No repeat attempt was possible, because no other tooth would ever be found with the same challenge, so procedural endodontic training had always been a random walk through the endo anatomy of patients’ teeth. In the endodontic training era that just expired, it took about 250 to 500 RCT cases (me too) before the frequency of getting surprised by a new anatomic challenge began to wane. Now, students can launch themselves at the same anatomic challenge as many times as it takes for them to have it nailed. Attack the same 90-degree apical impediment in a DB root canal of an upper molar 15 to 20 times — with the same, exact challenge every time — and you will be the king of 90-degree apical canal curvatures thereafter. Now, even orthodontists can learn to do a mean RCT. This is a serious game changer for endodontic educators.

2) TrueTooth replicas are very effective when used in clear and then opaque form to teach mental imaging skills. I begin each of my hands-on courses with a mental imaging exercise in a clear TrueTooth replica of a maxillary central incisor that has an apical canal bifurcation. I teach course attendees how to accurately bend K-files to enter and traverse that accessory canal, and I have seen this particular use of these replicas shorten students’ timeline to competence as they watch all the idiosyncrasies of file function while working in an anatomically accurate canal space.

Students are able to see the bent file tip snapping past the accessory canal orifice at the same time they distinctly feel the attendant “click” of the file tip dropping into the secondary canal, and after a couple of tries they become proficient in negotiating into accessory canals with visual and tactile feedback.

The next challenge is to remove the visual feedback loop by changing to an opaque TrueTooth replica, and invite the student to enter the same secondary canal anatomy by just feel instead of vision and feel. After conquering that challenge, they know how to correctly bend files and blindly sneak them into secondary anatomy using mental imaging to interpret the tactile feedback coming through the handle of the file.

After this exercise, it is a relatively short path to accomplishment of the same in a patient’s root canal system. Mental imaging is the most important skill a dentist can bring to bear during RCT. For the first time we have a reproducible method of transferring this critical skillset. A game changer for sure.

3) While softer than extracted teeth, the heat-resistant polymer used to print TrueTooth replicas cuts crisply with high-speed handpieces — without gumming up burs.

At Dental Education Laboratories, we set the HS handpieces at one-third the typical RPM — giving the participant more authentic tactile resistance.

‘This new technology can easily replace extracted teeth and unauthentic models in endodontic training.’
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during access procedures. Also, while the TrueTooth replicas are more easily ledged than extracted teeth, I have found they are the equivalent of swinging two baseball bats on deck before going up to the plate against a pitcher.

If you can navigate these anatomically authentic replica canals without ledging any of the natural irregularities contained within, you are ready for prime time in real teeth, as you will have developed the requisite light touch all successful endodontists have. This is a more subtle advantage than those mentioned above, but no less helpful to educators, nonetheless.

When students use training models with canals that resemble a soda straw, students gain no experience in ledge avoidance — a vital skill they desperately need as they move from pre-clinical lab to clinic and start invading their patient’s teeth. These replicas deliver anatomically accurate training in a way never previously possible.

4) Now, educators can develop a procedural training curriculum around a series of classic anatomic tooth forms that walk undergraduate dental students through the most common endodontic challenges they will encounter in practice, as well as more difficult cases that can lead graduate students through a range of anatomic challenges they could not meet in five years of practice.

Now, course objectives met by each student are easily documented, a necessity for accreditation review.

5) Replicas can be designed and printed for surgical training, complete with soft tissue that can be incised, reflected and sutured; hard and soft bone tissues, as well as roots and their canals — all printed together with no assembly required — are encountered exactly as they are in a surgical procedure (see “A New paradigm in surgical training,” roots, Issue 1, 2014).

6) Replicas can be created with multiple versions at the same level of difficulty to provide a diversity of experience for students, and still other versions for testing replicas that are only available to educators and examining boards. For procedural testing to be fair to students, educators and examiners, they are all served by authentic, reproducible 3-D printed replicas.

With our modeling engineers and our new multi-ink printer, our goal is to build replicas of quadrants and full arches with a different TrueTooth replicas in every tooth position.

I’ve made the case that this new technology can easily replace extracted teeth and unauthentic models in endodontic training. Dental education just got better, but the home run of this new tool will inevitably bring educational applications never before imagined. Dental education will never be the same.

The Dental Education Laboratories website, DELendo.com, has a complete catalog of the 30-plus different TrueTooth replicas currently available; however if you don’t see a TrueTooth replica that rings your chimes — whatever the need — let us know.

about the author

L. Stephen Buchanan, DDS, FICD, FACD, is a diplomate of the American Board of Endodontics and an assistant clinical professor at the postgraduate endodontic programs at USC and UCLA. He maintains a private practice limited to endodontics and implant surgery in Santa Barbara, Calif., and is the founder of Dental Education Laboratories, a hands-on training center serving general dentists and endodontists who want to upgrade their skills in new endodontic and implant technology. Dr. Buchanan can be reached through his business, Dental Education Laboratories, www.DELendo.com, info@endobuchanan.com.
As a patient, I expect the best care I can find. As a doctor, I want to deliver the best care possible. That takes us to the power of continuing education, and as doctors we are faced with many choices in continuing education.

As a way to introduce you to the Las Vegas Institute for Advanced Dental Studies, or LVI, I want to outline what LVI is about and what void it fills in your practice. The alumni who have completed programs at LVI were given an independent survey, and unlike the typical surveys, 99.7 percent said they love practicing dentistry, and of those surveyed, 92 percent said they enjoy their profession more since they started their training at LVI. That alone is reason enough to go to LVI and find out more.

While the programs at LVI cover the full breadth of dentistry, the most powerful and life-changing program is generally reported as being Core I, or Advanced Functional Dentistry — The Power of Physiologic-Based Occlusion. This program is a three-day course that is designed for doctors and their teams to learn together about the power of getting their patients’ physiology on their side. In this program, doctors can learn how to start the process of taking control of their practice and start to enjoy the full benefits of owning their practice and providing high-quality dentistry.

Whether he or she works in a solo practice or in a group setting, every doctor can start the process of creating comprehensive care experiences for his or her patients.

We will discuss why some cases that doctors are asked by their patients to do are actually dangerous cases to restore cosmetically. We will discover the developmental science behind how unattractive smiles evolve and what cases may need the help of auxiliary health care professionals to get the patient feeling better. The impact of musculoskeletal signs and symptoms will be explored and how the supporting soft tissue is the most important diagnostic tool you have. Not simply the gingiva, but the entire soft-tissue support of the structures not just in the mouth but also in the rest of the body.

A successful restorative practice should not be built on insurance reimbursement schedules. An independent business should stand not on the whims and distractions of a fee schedule but rather on the ideal benefits of comprehensive care balanced by the patients’ needs and desires.

Dentistry is a challenging and thankless business, but it doesn’t have to be. Through complete and comprehensive diagnosis, there is an amazing world of thank-yous and hugs and tears that our patients bring to us, but only when we can change their lives. The Core I program at LVI is the first step on that journey.

That’s why when you call, we will answer the phone, “LVI, where lives are changing daily!”
Introducing GentleWave

Scheduled to make its debut at the 2014 AAE Annual Session, the GentleWave™ System utilizes patented Multisonic Ultracleaning™ technology that is designed to quickly, easily and safely loosen and remove pulp tissue, debris, decay and bacteria within minutes. The system is designed to clean the entire canal system, automatically and simultaneously.

New paradigm

Because the GentleWave System has the ability to clean in such a comprehensive way, less traditional instrumentation is required, creating the potential to dramatically reduce procedure time. The minimally invasive procedure also allows the opportunity to remove less structural dentin, helping to preserve the structural integrity of the tooth.

Bjarne Bergheim, president and CEO of Sonendo, has been directly involved in the development of the GentleWave since its early inception.

“Very soon, endodontists performing root canal therapy will have the ability to provide an ultraclean environment for their patients in a more comprehensive, efficient and predictable way,” Bergheim said. “We remain focused on creating a new standard of care for the patient as well as improving the clinical quality and business performance of doctors performing root canal therapy.”

About Sonendo and Sound Science

Sonendo’s commitment to Sound Science® ensures that its product development is based on sound scientific research and extensive proof source. Furthermore, the company will continue to leverage its innovative approach to sound — and its use in endodontics — as it works to bring this new technology to the endodontic community.

In summary, Sonendo is focused on bringing to market a device that will provide an endodontic treatment that is highly predictable for every procedure, more comfortable for the patient, faster and more efficient for the practice, and offering a significantly cleaner disinfected treatment area compared with current standards.

Come see Sonendo

Those doctors attending the AAE Annual Session in April will have a chance to learn more. Dr. Mehrzad Khakpour will offer a presentation on Sonendo’s Multisonic Ultracleaning technology on Wednesday, April 30, from 2 to 3 p.m. in the exhibit hall. AAE attendees will also be able to view the system and take part in demonstrations as Sonendo unveils the GentleWave at booth No. 823. For more information, visit www.sonendo.com.

Sonendo’s system is not yet commercially available for sale or distribution.
Introducing Grey MTA Plus — ‘Reshaping’ root canal practices everywhere

Author: Avalon Biomed staff

Avalon Biomed Inc. is introducing its first dental product, Grey MTA Plus. The bioactive root and pulp treatment material helps heal injured vital pulp and also treats various endodontic conditions. Grey MTA Plus represents the next generation of the tricalcium silicate materials and is composed of a fine, non-gritty powder and a unique gel. While most other MTAs include water, the MTA Plus gel enables the MTA powder to set faster and be washout-resistant within five minutes. The gel and fine powder allow the clinician to easily create the consistency desired. The powder-to-gel ratio can be varied so that the clinician can create putty-like, creamy paste or a sealer consistency.

The benefits of MTA (tricalcium silicate)-based products are well established for a multitude of endodontic procedures, ranging from perforation repair to root-end filling, and also for vital pulp therapy. Grey MTA Plus is indicated for vital pulp procedures, including pulp-capping, cavity lining and use as a base. Additionally, Grey MTA Plus can be used for root-canal sealing, revascularization or for obturation when extraction is the only alternative.

The silvery color of Grey MTA Plus is beneficial for distinguishing the material when placed, and the color makes the material slightly more radiopaque than other white MTA materials. The product was tested internationally beginning in 2011, and case reports show the healing effect that results from the bioactive tricalcium silicate of MTA. When implanted, the material was equal to the best-known MTA.

The material is non-cytotoxic and is antibacterial when tested in vitro against common endodontic bacteria including *E. faecalis*. All components of the product are already used in dentistry and pulpal procedures. Articles on Grey MTA Plus are available at avalonbiomed.com. The Grey MTA Plus powder is packaged in a desiccant-lined bottle to keep the powder dry and allows the clinician to dispense only what is needed, avoiding waste. The dropper tip gel bottle is suitable for mixing small amounts.

Two kit sizes are available: 2.5 and 8 gram.

‘I like how the Grey MTA Plus mixes. The fine, particle-size powder combined with the special gel creates a material that has superior handling properties.’

— Prof. Karl F. Woodmansey, asst. professor, Department of Endodontics, Baylor College of Dentistry

Photo/Provided by Avalon Biomed Inc.

‘Feeling is believing; when you mix the powder and gel, the scratchy, gritty sound and feel is absent, and the handling of Grey MTA Plus is as easy as with IRM’. It’s designed to be an affordable, convenient MTA that performs for you and the patient.

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“I like how the Grey MTA Plus mixes. The fine, particle-size powder combined with the special gel creates a material that has superior handling properties.’

— Prof. Karl F. Woodmansey, asst. professor, Department of Endodontics, Baylor College of Dentistry
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Professor and Chair,
Division of Endodontics, School of Dental Medicine, University of Colorado

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Coordinator of Predoctoral Endodontic Program and Associate Dean for Advanced Education
School of Dental Medicine, University of Nevada, Las Vegas

"TrueTooth Replicas brought anatomic realism to our preclinical endodontics course!"

Division of Endodontics,
University of Minnesota, School of Dentistry

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