Endodontic irrigants and irrigant delivery systems

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By Gary Glassman, Canada

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 apexes and into 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 irrigation 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.1 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.2 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 periodontal lesions.3,4 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).

The challenge for successful endodontic treatment is that a variety of factors, such as the presence of necrotic remnants of pulp and bacteria, the dentin smear layer, microorganisms and toxins from the root-canal system.5,6 Even with the use of rotary instrumentation, the metallic osmium currently available only act on the central body of the root, resulting in a reliance on irrigation to clean beyond what may be achieved by rotary instrumentation in addition. Enterococcus faecalis and Actinomyces prevention or removal becomes a challenge such as Enterococci israelii — which are both implicated in endodontic infections and in endodontic failure — penetrate deep into dentinal tubules, making their removal through a methodical instrumentation impossible.3,7,8 Finally, E. faecalis commonly expresses multidrug resistance.9,10,11,12 Moreover, 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).

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Apical vapor lock

Because the root canal is surrounded by the periodontium, and unless the root canal foramen is opened, the root canal behaves like a closed-ended channel. This produces an apical vapor lock that resists displacement during canal preparation and final irrigation, thus preventing the flow of irrigant into the apical zone. Irrigating fluids are then trapped, with mechanical instrumentation, such as lateral canals and isthmuses. Therefore, during irrigating the apical third, the phenomenon of apical vapor lock should be considered.19–24

Apical vapor lock also results in gas entrapment at the apical third.3 During irrigation, NaOCl reacts with organic tissue in the root-canal system, and the resulting hydrolysis liberates átomos of chlorine (Cl), chlorine gas (Cl2), and carbon dioxide (CO2).25 This gaseous mixture is trapped in the apical region and quickly forms a column of gas into which further fluid penetration is minimal.26 The use of instruments in this vapor lock does not reduce or remove the gas trapped, because the canal must be flared to ensure adequate flow of irrigant.27

The phenomenon of apical vapor lock has been confirmed in studies in which roots were embedded in agar or polyethylene to reduce the movement of irrigant.28,29 The presence of an apical vapor lock, as determined by Micro-CT scanning and histological tests conducted by Tay et al.30,31 have also confirmed the presence of apical vapor lock.32

In fact, studies conducted with root samples in which the apical third of the canal walls with the use of a positive-pressure syringe device demonstrated an apical vapor lock.13

Manual irrigation

Manual 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 hydraulic effect and significant irrigant exchange.13,33–35 Recent studies have demonstrated that this irrigation technique is significantly more effective than automated dynamic irrigation and static irrigation.36–40

Ultrasonics

Ultrasonic energy produces higher frequencies than sonic energy but low amplitudes, oscillating at frequencies of 25–50 kHz.41,42 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).43 The literature indicates that irrigation using ultrasonics after completion of canal preparation rather than as an alternative to conventional instrumentation.44,45 PUI irrigation allows energy to be transmitted from an oscillating file or smooth wire to irrigate to the root canal by means of ultrasonic vibrations.46,47 It is important to realize that PUI is more effective than the conventional endodontic needle in delivering irrigation to the root canal.48 This raises the efficacy question. Two recently published studies requested additional evidence to apply this technique with instruments using PUI with #15 files and MicroCannula. The Master Delivery Tip (Fig. 2), MacroCannula and MicroCannula. The Master Delivery Tip is a semi-open tip that incorporates it into their endodontic instrumentation armamentarium. The common reasons given for not using sonic or ultrasonic techniques are the newness of the technique and a lack of willingness to incur the cost of the equipment. Therefore, the goal is to sensitize the apical zone by a hydraulic effect to remove the smear layer and allow effective irrigational flow of the medicament.49

The plastic rotary F1 File

Although sonic or ultrasonic instrumentation is more effective at removing residual canal debris than rotary endodontic files are, and irrigation solutions are often used to enhance the hydrodynamic effect resulting from this endodontic treatment, many clinicians still do not incorporate it into their endodontic instrumentation armamentarium. This is mostly because of an endodontic polymer-based rotary file was developed. The new, single-use, plastic rotary file has a unique file design with a diamond abrasive embedded into a non-toxic polymer. The F1 File will remove dentinal wall debris and agitate the NaOCl without enlarging the canal further.50

Pressure-alternation devices

Rinsendo irrigates the canal by using pressure-alternation technology. Its components are a handpiece, a cannula with a 0.014 inch exit aperture, and pressure-syringe carrying the irrigant. The handpiece is powered by a dental air syringe, capable of delivering a pressure of 6.2 ml per minute. Research has shown that it has no adverse effect on the root-canal system, but more research is required to provide additional evidence of its efficacy. Periapical extrusion of irrigant has been reported with this device.51–54

The EndoVac apical negative-pressure irrigation system

The EndoVac apical negative-pressure irrigation system has three components: the Master Delivery Tip, MacroCannula and MicroCannula. The Master Delivery Tip is a semi-open tip that incorporates the apical canal into the apical zone by a hydraulic effect to remove the smear layer and allow effective irrigational flow of the medicament.49

Studies have demonstrated that effective delivery of irrigants to the apical third can be enhanced by using ultrasonic and sonic devices that produce acoustic micro-streaming and cavitation.55–59 Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the ultrasound exposure.60,61 Cavitation is the formation of gas and vapor bubbles or cavities in a fluid. The Apical Vapor Lock theory, proven in vitro by Tsai, has been clinically demonstrated to also include the middle third by Venez: “The mixture of gases is originally trapped in the apical third, but then it might grow quickly by the necration of the smaller bubbles, forming a 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.”9

When questioning these divergent results, one must remember that microbial hydrolysation via NaOCl is an equilibrium reaction. Hand demonstrated that the use of NaOCl as an alternative to conventional irrigation operating without simultaneous irrigation (PUI) and EndoVac are more effective than the conventional endodontic needle in delivering irrigation to the root canal.50 This raises the efficacy question. Two recently published studies requested additional evidence to apply this technique with instruments using PUI with #15 files and MicroCannula. The Master Delivery Tip is a semi-open tip that incorporates it into their endodontic instrumentation armamentarium. The common reasons given for not using sonic or ultrasonic techniques are the newness of the technique and a lack of willingness to incur the cost of the equipment. Therefore, the goal is to sensitize the apical zone by a hydraulic effect to remove the smear layer and allow effective irrigational flow of the medicament.49

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with a 0.02 taper and is attached to a handpiece for gross, initial flaring and irrigation to lengthen the cutting lengths part of the root canal. The MicroCanna contains 12 microscopic holes and is capable of evacuating debris to full working length.20

The 0.04 mm diameter stainless-steel MicroCanna has four sets of three laser-cut, laterally positioned offset holes adjacent to its closed end, 100 μm in diameter and spaced 100 μm apart. This is attached to a first piece for irrigation of the apical part of the canal when it is positioned at working length. The MicroCanna can be used in canals that are enlarged with hand files to ISO size 55.04 or larger.

During irrigation, the Master Delivery Tip is used to advance the palpatory channel and spines off the excess irrigant to prevent over-ventilation. Both the Master Delivery Tip and MicroCanna exert negative pressure that pulls fresh irrigant from channels down the canal to the tip of the cannula, into the cannula, and out through the suction. Correct use of the Master Delivery Tip is mandatory to prevent fresh irrigant delivered by negative pressure to working length from recent apical irrigants to use the volume of irrigant delivered was significantly higher than the volume delivered by conventional syringe needle irrigation within the same period.21

This extensive trauma, and periodically more debris removal at 1 mm from working length than did at 1.5 mm from working length.24

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 allowing the needle to close to working length, and using a gentle flow rate when using positive pressure.25 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 reach the apical third and help overcome apical vapor lock.26,27 In addition, with respect to irrigation cleanliness, it is not possible to reach and clean the isthmus without it; however, it is possible to reach and clean the apical third and help overcome apical vapor lock.26,27


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This article has been reprinted in part from G. Glassman, Safety and Efficacy Considerations of Apical Negative Pressure Irrigation (Pen-Well, June 2011).

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Fig. 2: EndoVac setup. (Images/Provided by Gary Glassman, DDS, DFN/DCC)

This page does not include NaOCl use when it is established.108 The associated cytotoxic effects of NaOCl incidents include not known. Mitchell and Baumgartner tested the effect of NaOCl on teeth using pressure before NaOCl is delivered to a root canal sealed with an apical negative-pressure irrigating fluid delivery device.114 When the NaOCl had been introduced into the root canal and quickly reacts with organic material forms micro-bubbles at the apex.102 The study concluded that they were carrying the irrigant to the apical terminus. Biological, scanning electron microscopic, and other studies have proven this belief to be in error. NaOCl reacts with dentin to form a hard 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 instrument. Because the apical vapor lock can be viewed via visual means, it pre- vents 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 irrigation. This method has also been proven to be safe because it always draws irrigants to the tip of the needle — down the canal and simul- taneously away from the apical terminus.28 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 be- fore.

References


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