

EndoVac™

Apical Negative Pressure: Safe and Effective Endodontic Irrigation from Beginning to END

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The ultimate goal of endodontic treatment is the prevention and/or treatment of apical periodontitis; such that there is complete healing and absence of infection¹ while the overall long-term goal is the placement of a definitive, clinically successful restoration and preservation of the tooth.

Successful endodontic treatment depends on a number of factors, including proper instrumentation, successful irrigation and decontamination of the root-canal system right to the apical terminus, in addition to hard to reach areas such as isthmuses and lateral and accessory canals². (Fig. 1)

The challenge for successful endodontic treatment has always been the removal of vital and necrotic remnants of pulp tissue, debris generated during instrumentation, the smear layer, micro-organisms and micro-toxins from the root-canal system.³

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.⁴

Dual irrigants such as NaOCl and EDTA are often used as initial and final rinses to circumvent the shortcomings of a single irrigant.⁵⁻⁷ These irrigants must be brought into direct contact with the entire canal-wall surfaces for effective action,^{8,5,9} particularly in the apical portions of small root-canals, where most of the lateral canals and canal ramifications exist.^{9,47}

The combination of NaOCl and EDTA has been accepted as the “gold standard” and used worldwide for antisepsis of root-canal systems. The concentration of NaOCl used for root-canal irrigation ranges from 0.5 to 6 percent,⁴⁸ depend-

ing on the country and local regulations; it has been shown, however, that tissue hydrolysis 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 favour superior microbial outcomes.¹⁰ NaOCl has a broad antimicrobial spectrum,⁸ including *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,^{11,12} which will allow further irrigation with NaOCl to penetrate deep into the dentinal tubules.¹³

Apical Vapour Lock

Unless the root-canal foramen is wide open, the root-canal behaves like a close-ended channel since the roots are surrounded by the periodontium. This produces an apical vapour lock, gas entrapment at the apical one third³, 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.^{14,15} During irrigation, NaOCl reacts with organic tissue in the root-canal system and the resulting hydrolysis liberates abundant quantities of ammonia and carbon dioxide.¹⁶ This gaseous mixture is trapped in the apical region and quickly forms a column of gas into which further fluid penetration is impossible. Extension of instruments into this vapour lock does not reduce or remove the gas bubble,¹⁷ just as it does not enable adequate flow of irrigant. Equally important is the concept that IF the NaOCl irrigant is NOT exchanged, the organic pulpal tissue will consume the NaOCl very quickly during the reaction of hydrolysis and in very short order, all that is left over is water, which has no tissue dissolving effects at all.

The phenomenon of apical vapour 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 close-ended channel. The results of these studies was incomplete debridement of the apical part of the canal walls with the use of a positive-pressure syringe delivery technique.¹⁸⁻²¹ Micro-CT scanning and histological tests conducted by Tay et al. have also confirmed the presence of apical vapour lock.²¹ In fact, studies conducted without ensuring a close-ended channel cannot be regarded as conclusive on the efficacy of irrigants and the irrigant system.²²⁻²⁴ The apical vapour lock may also explain why in a number of studies investigators were unable to demonstrate a clean apical third in sealed root-canals.^{20,25-27}

In a paper published in 1983, 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.²⁸ 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”.²⁸ The apical vapour 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,²⁹ and do it in a safe manner that prevents the extrusion of irrigant.

Safety Precautions and the Irrigation Accident

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 root-canal irrigation. Furthermore, Salzgeber reported in the 1970s that apical extrusion of an endodontic irrigant routinely occurred *in vivo*.³⁰

Although a devastating endodontic NaOCl incident is rare,³¹ the cytotoxic effects of



Micro-CT images of a maxillary molar demonstrate the root canal complexity. (Courtesy Dr. Ronald Ordinola Zapata, Brazil.)



Upper left cuspid from Mehra. (46) Most edematous and hemorrhagic effects of published NaOCl incidents are hemifacial. Although bilateral circumorbital ecchymosis is not uncommon, this case clearly demonstrates a vascular connection via superficial nasal veins (arrow) between both left and right circumorbital venous complexes suggesting that the NaOCl followed the venous connection across the bridge of the nose. (Reproduced with permission of Elsevier)



The Master Delivery Tip (MDT) accommodates different sizes of syringes filled with irrigant, the macro cannula is attached to the autoclavable aluminium hand piece and the micro cannula is attached to an autoclavable aluminium finger piece. The macro cannula, the micro cannula and the MDT are connected via clear plastic tubing. The tubes are connected to the high volume suction of the dental chair via the Multi-Port Adaptor.

NaOCl on vital tissue are well established.³² The associated sequelae of NaOCl extrusion have been reported to include life-threatening airway obstructions,³³ facial disfigurement requiring multiple corrective surgical procedures,³⁴ permanent paraesthesia with loss of facial muscle control,³⁵ tooth loss³⁶ and post-operative pain.⁴⁹

The mechanism of action for the hypothesis of an irrigation accident is that it involves the intravenous infusion of extruded NaOCl into the facial vein via non-collapsible venous sinusoids within the cancellous bone³⁷.

(Fig. 2)

This does not imply that NaOCl can or should be excluded as an end-



Microcannula. The ISO size 0.32 mm external diameter stainless-steel micro cannula of zero taper has four sets of three laser-cut, laterally positioned offset holes adjacent to its closed end, 100 microns in diameter and spaced 100 microns apart. (Courtesy Dr. G John Schoeffel)

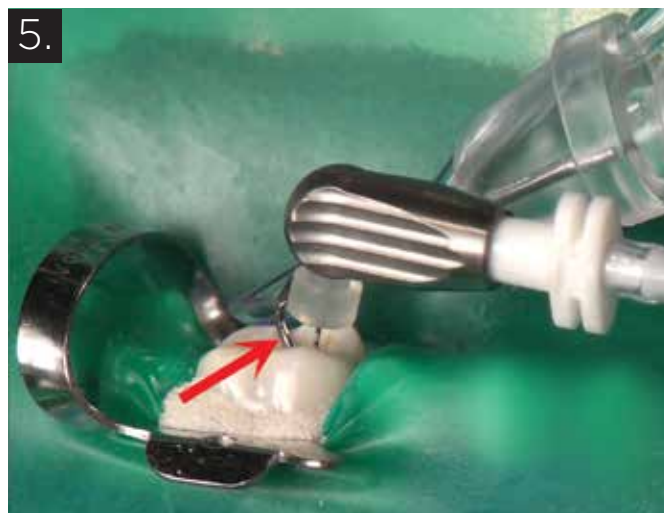
odontic irrigant; in fact, its use is essential to achieve adequate chemical debridement. What this does imply is that it must be delivered safely.

The conundrum that the clinician faces is to SAFELY and effectively deliver the irrigants to the apical terminus, break the Apical Vapour Lock and allow constant exchange of irrigant and thereby continual hydrolysis of pulpal tissue by the NaOCl WITHOUT the risk of apical extrusion.

The EndoVac™ System: Apical Negative Pressure

The EndoVac™ system was developed to safely and predictably deliver irrigants to the apical terminus thereby allowing a better penetration of the irrigation solution into the inherent anatomy and morphology of the root-canal system; such as isthmuses, inter-canal and intra-canal communications, curvatures and oval shaped canals. All these anatomic irregularities make disinfection of the root-canal extremely challenging.²⁹ Apical negative pressure systems for irrigation have the ability to suction, thereby drawing and delivering the irrigant passively to the apex.³ The EndoVac™ system delivers the chosen irrigant passively to the apex^{29,38} and positively addresses the problem of irrigation penetration past the apex into the periapical tissue, which may result in treatment complications.^{37,39,40}

The EndoVac™ apical negative-pressure irrigation system has three active component parts: the Master Delivery Tip (MDT), the macro cannula and the micro cannula. (Fig. 3) The MDT accommodates a syringe of irrigant, which is expressed through a 20-gauge needle. There is also a plastic suction hood attached around the 20-gauge needle that is connected to clear plastic tubing, which inserts into a multiport adaptor and then is inserted into the high volume suction.¹⁷ As such, the MDT can simultaneously deliver and evacuate any excess irrigant that may flow over from the pulp chamber. The macro cannula is used to draw irrigant by way of suction from the chamber to the coronal and middle segments of the canal while irrigant is simultaneously delivered to the pulp chamber directed towards an axial wall and never towards a canal orifice. The macro cannula or micro cannula is connected via clear plastic tubing to the high-speed suction

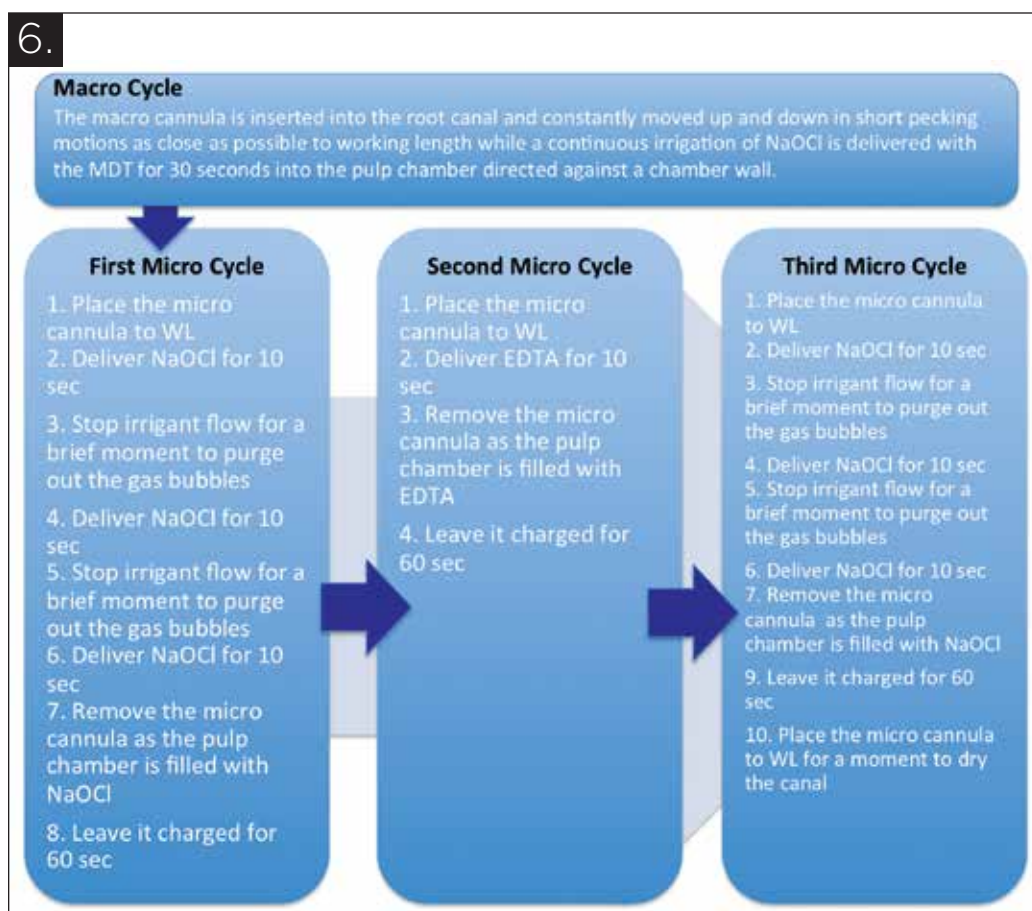


Once the micro cannula is placed at full working length, the clinician may leave it in place after stabilizing the plastic tubing and proceed with irrigant delivery via the MDT. The clinician may put a slight bend on the MicroCannula if it won't stay in the canal on its own. (Courtesy Kerr Endodontics (SybronEndo). Orange, California)

of the dental unit by way of the multiport adaptor. The plastic macro cannula has an external diameter of ISO size 0.55 mm and an internal diameter of ISO size of 0.35 mm. It is made of blue translucent plastic, has a 0.02 taper and is meant for single patient use only. It is attached snug to an autoclavable aluminium handpiece and is used in an up and down pecking motion, while irrigant is simultaneously delivered passively to the pulp chamber in the manner mentioned above. It is used to remove the gross debris and tissue left behind during instrumentation. The micro cannula (Fig. 4) contains 12 microscopic holes and is capable of evacuating debris to full working length.⁴¹ The size 0.32 mm external diameter stainless-steel micro cannula of zero taper 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. These holes act as filters to prevent the clogging of the internal lumen of the micro cannula, which has an internal diameter of ISO size 0.20 mm. The micro cannula is attached to an autoclavable aluminum finger piece and is used for irrigation of the apical part of the canal when it is positioned at working length. The micro cannula has a closed end and should be taken to the full working length to aspirate irrigants and debris. The micro cannula can be used in canals that are enlarged with endodontic files to ISO size .35 mm with 0.04 taper or larger. A non-tapered preparation can also be considered; in this situation the manufacturer recommends an enlargement of the root-canal to 40/0.02.

During irrigation, the MDT delivers irrigant to the pulp chamber directed towards a chamber wall and siphons off the excess irrigant to prevent overflow. Both the macro cannula and micro cannula exert negative pressure that pulls fresh irrigant from the chamber, down the canal to the tip of the cannula, thru the holes at its tip and then into the cannu-

6.



Flow chart showing the final irrigation protocol using EndoVac™ system.

la's lumen, then out through the suction via the clear plastic tubing. A constant flow of fresh irrigant is thereby delivered by negative pressure (suction) to working length, allowing the reaction of hydrolysis to continually occur.

Method of use

Irrigation begins during rotary instrumentation. The MDT delivers fresh irrigant to the access opening when each instrument is changed in the handpiece. Using the MDT is optional during access and the instrumentation phases of root-canal treatment. A normal monoject syringe may be used to replenish the irrigant in the pulp chamber during instrumentation. This removes instrumentation debris and exchanges irrigant deep within the pulp chamber as subsequent files are brought closer and then finally to working length. When using the MDT, always direct the irrigant flow against a chamber wall. Never direct the flow of irrigant towards a canal's orifice as the pressure of irrigant expression has the potential of causing an irrigation accident in straight and wide canals even when the needle is not placed directly in the orifice or canal.

Following complete instrumentation, the macro cannula is used in each canal for 30 seconds in a short up and down pecking motion as close as possible to working length. Continue to deliver copious NaOCl with the MDT while the macro cannula is moving up and down the canal. Observe

the macro cannula for continuous flow and ensure it does not become blocked with debris. If it does, then remove the plastic tubing from the aluminium handle, place a syringe of water tightly at the end and express the water through the handle and macro cannula to dislodge the blockage. This is carefully done over the sink and not over the patient. This step can also be performed with the micro cannula should it become blocked. The use of the macro cannula in the final irrigation protocol will remove the gross debris and tissue left behind during instrumentation. If a shortcut is made and this step is not completed for the full 30 seconds in each canal then the micro cannula used in the next step may become blocked and slow down the irrigation process.

The next step involves three Micro Cycles. They are called Micro Cycles because the micro cannula is now used at full working length to remove debris from the canal lumen and isthmus areas. Use a ruler to position the rubber stopper that is placed on the micro cannula or score the micro cannula with an indelible marker. Delicately guide the micro cannula to full working length by holding the finger piece. The finger piece is then released and the tubing is stabilized. The NaOCl is added with the MDT to the pulp chamber for 10 seconds. (Fig. 5) After 10 seconds, the irrigant flow is stopped for just a couple of seconds to allow the gas bubbles formed by hydrolysis are purged from the canal. The NaOCl

is added for another 10 seconds after which the irrigant flow is stopped again to allow the gas bubbles to be purged from the canal. The NaOCl is then added for a third and final time for another 10 seconds, but at the end of this time period, the micro cannula is removed by the finger piece as the MDT continues to deliver NaOCl to the pulp chamber as to not allow its removal from the canal just being treated. This allows the canal to be charged (soaked) with fresh NaOCl for 60 seconds. The first Micro Cycle allows the organic component of the smear layer to be removed in addition to any fine debris left behind during instrumentation. The Second Micro Cycle using EDTA removes the inorganic component of the smear layer. The micro cannula is again delicately guided to full working length. EDTA is added for 10 seconds, and then the micro cannula is removed allowing the canal to be charged for 60 seconds. As mentioned, this will remove the inorganic component of the smear layer and expose the dentinal tubules in preparation for the Third Micro Cycle. The Third Micro Cycle is the same as the First Micro Cycle, two purges and a charge for 60 seconds. Now that the smear layer has been removed from the root-canal walls by the first two Micro Cycles, this third Micro Cycle will allow the NaOCl to enter the dentinal tubules via osmosis and dissolve the remaining tissue and microbiota.¹⁸ There is no better way to dry the root-canals then to delicately guide the micro cannula to full working length for just a moment. This is followed by one or two paper points. The canal(s) is/are now ready for obturation. Figure 6 is a flow chart illustrating the final irrigation protocol using the EndoVac™ system. It is worth noting that if the clinician prefers to use alternative irrigants for smear layer removal, microbial control and/or debridement then the microcannula can be used for this purpose.

Conclusion

The EndoVac™ endodontic irrigation system works on apical negative pressure. Apical negative pressure devices such as the EndoVac™ have been shown to enable irrigants to safely reach the apical one third in voluminous amounts, help overcome apical vapour lock (air entrapment at the apical one third), allow the continual reaction of hydrolysis to occur as well as remove tissue and bacteria throughout the root-canal system, all without the risk of extrusion into the periapical tissues.⁴²⁻⁴⁵ **OH**

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Oral Health welcomes this original article.

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