Endodontic irrigants and irrigant delivery systems

Dr Gary Glassman

With the introduction of modern techniques, success rates of up to 98 per cent 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,2 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.3 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 on the root canal system is a key factor for the development of periapical lesions.4,5

Additionally, the root canal system has a complex anatomy that consists of arborisations, isthmuses and cul-de-sacs that harbour organic tissue and bacterial contaminants (Fig. 1).6

The challenge for successful endodontic treatment has always been the removal of vital and necrotic remnants of pulp tissue, debris generated during instrumentation, the dentine smear layer, micro-organisms and micro-toxins from the root canal system.7

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.8

In addition, Enterococcus facalis and Actinomyces prevent treatment or arrest of apical periodontitis such as Actinomyces israelii which are both implicated in endodontic infections and in endodontic failure - penetrate deep into dentinal tubules, making their removal through mechanical instrumentation impossible.9,10 Finally, E. facalis commonly expresses multidrug resistance,11 compromising treatment.

Therefore, a suitable irrigant and irrigant delivery system are essential for efficient irrigation and the success of endodontic treatment.12 Root canal irrigants must not only be effective for dissolution of the organic of the dentinal 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 pulpal 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. facalis and A. israelii) are sensitive to it, and it is biocompatible, with no tissue toxicity to the periapical or surrounding tissue.13 Chlorhexidine gluconate, however, lacks the ability to dissolve necrotic tissue, which limits its usefulness. Hydrogen peroxide as a canal irrigant helps to remove debris from the physical action of irrigation, as well as through effervescing of the solution. However, while an effective anti-bacterial irrigant, hydrogen peroxide does not dissolve necrotic intracanal 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.14 Alcohol-based canal irrigants have antimicrobial activity too, but do not dissolve necrotic tissue.

The irrigant that satisfies most of the requirements for a root canal irrigant is NaOCl.15 It has the unique ability to dissolve necrotic tissue and the organic components of the smear layer.15 It also kills sessile endodontic pathogens organised in a biofilm.16,17 There is as other root canal irrigant that can meet all these requirements, even with the use of methods such as lowering the pH,18 increasing the temperature,19–21 or adding surfactants to increase the wetting efficacy of the irrigant.18,19

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.20

Calicifications hindering mechanical preparation are frequently encountered in the root canal system, further complicating treatment. Demineralising agents such as EDTA have therefore been recommended as adjuncts in root canal therapy.20,21 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.22,23 These irrigants must be brought into direct contact with the entire canal-wall surfaces for effective action.24 Particularly in the apical portions of small root canals.25

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 six per cent, depending 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 per cent NaOCl. The higher concentration may also favour superior microbiological outcomes. NaOCl has a broad antimicrobial spectrum, 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, which 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 minimise 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 side-vented needle. Machine-assisted irrigation techniques include sonics and ultrasonics, as well as newer systems such as the Endo-Vac (SybronEndo), which delivers apical negative-pressure irrigation, the plastic rotary F File (Plastic Endo), the Vibhringe (Vibhringe), the Rensendo (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 vapour lock should be considered.

Apical vapour lock Since roots are surrounded by the periodontium, and unless the root canal foramen is open, the root canal behaves like a close-ended channel. This produces an apical vapour 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 vapour 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 into which further fluid penetration is impossible. Extension of instruments into this vapour lock does not reduce or remove the gas bubble, just as it does not enable adequate flow of irrigant.

The phenomenon of apical vapour lock has been confirmed in studies in which roots were embedded in a polysiloxane impression material to restrict fluid flow through the apical foramen, simulating a close-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 vapour lock. In fact, studies conducted without ensuring a close-ended channel cannot be regarded as conclusive on the efficacy of irrigants and the
Irrigant system. The apical vapo-

In a paper published in 1985, based on research by Chow, it was 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 inductive 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 vapour lock and consideration for the patient’s safety have always prevented the thorough cleaning of the apical 3mm. 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. However, the closer the needle tip is positioned to the apical tissue, the greater the chance of apical extrusion of the irrigant. This must be avoided, were NaOCl to extrude past the apex, a catastrophic accident could occur.

Manual-dynamic irrigation

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

Machine-assisted agitation systems

Sonic irrigation - Sonic activation has been shown to be an effective method for disinfecting root canals, operating at frequencies of 1–6kHz. 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. 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.

Ultrasonics - Ultrasonic energy produces higher frequencies than sonic energy but low amplitudes, oscillating at frequencies of 25–50kHz. 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 ultrasonics after completion of canal preparation rather than as an alternative to conventional instrumentation.

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. There is consensus that PUI is more effective than syringe needle irrigation at removing pulpal tissue remnants and dentine debris. This may be due to the much higher velocity and volume of irrigant flow that are created in the canal during ultrasonic irrigation. PUI has been shown to remove the smear layer; there is a large body of evidence with different concentrations of NaOCl. 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 or achieves significantly better results than syringe needle irrigation.
to the apical third can be enhanced by using ultrasonic and sonic devices that demonstrate acoustic micro-streaming and cavitation.88-90 Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the superimposed energy and mechanical pressure changes within the tissue. Cavitation is defined as the formation and collapse of microbubbles or cavities in a fluid.

The Apical Vapour Lock theory, proposed by Taylor and Gondim et al. clinically demonstrated,10 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 only impede penetration of the irrigant into the apical third but also push it coronally after it has been delivered into the canal. There, it is recently demonstrated by Munoz11 that passive ultrasonic irrigation (PUI) and EndoVac are more effective than the use of a conically shaped needle in delivering irrigant to WL of root canals.”

This begs 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.94,95 Paiva found that after a supplementary instrumentation session, the MicroCannula has been shown to provide scientific evidence of its effectiveness in the middle third but also push it coronally after it has been delivered into the canal. Research has shown that it has promising results in the apical third and help overcome apical vapour lock.11,112

The EndoVac apical negative-pressure irrigation system has three components: the Master Delivery Tip, MacroCannula and MicroCannula. The Master Delivery Tip simultaneously cavitates 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 MicroCannula 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. The evacuation of the irrigant into the apical part of the canal is performed by the suction device directly into the Master Delivery Tip. The suction device is pulled into the canal at high-speed suction of a dental unit. The plastic MacroCannula has an open end of ISO size 0.55mm in diameter with a 0.02 taper and is attached to a handpiece for gross, initial flushing of the canal and mid-length parts of the root canal. The MicroCannula contains 12 microscopic holes and is capable of evacuating debris to full working length.106

The ISO size 0.52mm diameter stainless-steel MicroCannula has four sets of laser-cut, laterally positioned offset holes adjacent to its closed end.106

As the irrigation is performed, the irrigant found its way into the venous complex. This would require positive pressure apical irrigation.103 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 allow irrigant to reach the apical third and help overcome apical vapour lock.11,112

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,105 passive ultrasonic,105 the F File,106 the manual-dynamic Max-i-Probe (DENTSPLY Rinn),106,107 the Pressure Ultrasonic114 and the EndoVac,106 only the EndoVac was capable of cleaning 100 per cent 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 egress into the periapical area106 thereby avoiding NaOCl incidents. It is important to note that it is possible to create positive pressure in the pulp chamber in the unlikely case scenario of apical egress,106 thereby avoiding needle penetration. 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,10 the cytotoxic effects of NaOCl on vital tissue are well established.114 The associated sequelae of NaOCl exposure have been reported to include threatening airway obstructions,114 facial disfigurement requiring multiple corrective surgical procedures,115 permanent paralysis, loss of facial muscle control,114 and - the least significant consequence - tooth loss.114

Although the exact aetiology of the NaOCl incident is still uncertain, based on the evidence from actual incidents and observations of the associated tissue trauma, it would appear that an intravenous injection may be the cause. The extensiveness of these injuries, particularly involving the pattern of ecchymosis around the eye, could only have occurred if the NaOCl had been introduced intravenously to a vein close to the root apex through which extrusion of the NaOCl occurred over a period of time. The irrigant then found its way into the venous complex. This would require positive pressure apical irrigation 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.114

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 deep intra- and extra-oral 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.106 The study concluded that the EndoVac did not extrude irrigant after deep intra- and extra-oral irrigation 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 EndoVac and MicroCannula.116 There was no significant extrusion occurring between the EndoVac system compared with positive pressure needle irrigation. A well-controlled study conducted by Gondim et al. found that patients experienced less post-operative pain, measured objectively and subjectively, when apical negative-pressure irrigation was performed (EndoVac) than with apical positive-pressure irrigation.117 Efficacy

The volume delivered by conventional syringe needle irrigation within the same period,10 resulted in significantly more debris removal at 1mm from working length than 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.103 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 vapour lock.11,112

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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 1.5mm from working length using apical negative pressure compared to use of traditional needle irrigation, while Shim et al. found in an in vitro study of 69 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 3.5mm from working length.115,116

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
Hoeckel 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.118

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.119

In a study comparing the use of apical positive-pressure irrigation and a triple antibiotic that has been utilised for pulpal regeneration/vascularisation 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 mineralised tissue formation and the repair process.120 Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discolouration, and allergic reactions.121,122

Conclusion
Since the dawn of contemporary endodontics, dentists have been straining 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 vapour bubble with subsequent instrumentation. Since the apical vapour 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 vapour 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.123 When the proper irrigating agents are delivered safely to the full extent of the root canal terminus, thereby removing 100 per cent of organic tissue and 100 per cent of the microbial contaminants, success in endodontic treatment may be taken to levels never seen before.124

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 (PenHill, January 2011).

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**About the author**

Dr Gary Glassman graduated from the University of Toronto Faculty of Dentistry in 1984 and graduated from the Endodontology Program at Temple University in 1987, where he received the Louis L. Grossman Study Club Award for academic and clinical achievement. He is author of numerous publications, he lectures globally on endodontics and is on the staff at the University of Toronto Faculty of Dentistry in the Graduate Department of Endodontics. He is a fellow of the Royal College of Dentists of Canada, and the endodontic editor for the Oral Health journal. He maintains a private practice, Endodontic Specialists, in Toronto, Ontario, Canada. He can be reached through his website, www.rootcanals.ca

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How did you learn about N2?
During my years of study at the University of Bonn, Germany (May 1959 – February 1965) N2 was the preferred root canal filling material of the dental clinic. When assisting in my father’s dental practice I used to work with N2 as well – occasionally replaced by Endomethasone, Riebler and Diaket.

Since when have you been familiar with the method developed by Dr. Sargenti?
I first learned about the Sargenti method in the years 1968 – 1970. This method convinced me as it is efficient and time-saving, which was very convenient for me as I had opened my own dental practice in July 1969 and never knew how to cope with the heavy patient traffic. So I was forced to think about measures to work efficiently – not only in endodontics. From April 1972 I worked with an assistant according to my instructions. Since the day
of opening my practice, all of mine and the assistant's dental treatments have been recorded. All of these practice diaries do still exist, however, the patient's file cards are no longer complete. So I was able to count the number of endodontic treatments.

How many root canal treatments have you done so far? I did 16,588 endodontic treatments with N2 in permanent teeth from 7/1969 to 12/2005. My assistants made it to 10,456

"Since the day of opening my practice, all of mine and the assistant's dental treatments have been recorded"

N2 endodontic treatments in the time from 04/1972 to 12/2001. For comparison: In his book “Endodontic Therapy” (5th ed., 1998), the renowned endodontist Weine reports about 18,500 endodontic treatments he had personally done.

Only 22 (five done by myself, 17 by an assistant) out of more than 8,800 computerised vital endodontic treatments between the years 1985 – 1999 required more than one appointment. I haven’t counted thousands of vital amputations and endodontic treatments of deciduous teeth.

How are your experiences with these cases? Several times I tried to treat deciduous teeth with Ca (OH)2. I judged the subsequent pain rate as being too high. It applies to all (dental) medical disciplines that the practitioner virtually loses face the more a patient has to see the doctor because of unsolved problems (pain after endodontic treatment, surgery, pressure marks).

How were you convinced to use N2 permanently? If not overfilled, a vital endodontic treatment with N2 never ends up in pain, including endo treatment of deciduous teeth.

How did you get into contact with Dr. Sargenti? I wanted to meet Dr. Sargenti whilst on vacation in Switzerland in 1989. He gave me quite a short shrift at his doorstep. In the year 1990, it was Dr. Sargenti who asked me for contact. He had suffered from a stroke and was in need of help. He knew that I had done a lot of endo...
treatments and due to this experience he asked me to represent the N2 method in German speaking countries. After I had studied the endodontic scientific literature, prepared a lecture in English and presented untried treatment cases to the AES (American Endodontic Society; professional association of N2 users in the US), Sargenti paid for my trip to an AES session in the United States, where I received the “fellowship”. After presentation of yet another lecture, I had to travel to 40 completed cases I was bestowed the title of “mastership”.

My mentioning of more than 10,000 treatments does not necessarily mean that they all met high quality standards. Root canal treatment of molars was quite in disorder. Until mid of 1985, however, X-ray control directly after root canal treatment was only done in exceptional cases, so we did not know what we were doing. Consequently, frequent failures due to poor root filling quality could be observed after years. At least this proved that the Sargenti method does not necessarily protect against failures due to poor root filling quality. In case of heavy overfilling, I prophylactically made a “Scheroder Airation” (= artificial fistulation). In most of the cases, gangrenous teeth could also be treated in one appointment. In case of short root filling, I finished treatment by apectomy; the other teeth were treated by trephination.

Whether apectomy or trephination – 2 – treatment has to be done efficiently without much fumbling to avoid subsequent problems. Acute exacerbations do very rarely occur after apectomy/trephination. I occasionally treated a “via falsa” with perforation and N2 leakage into the bone successfully by fistulation as well. I use the expression “occasionally” as this happened only very rarely, thus there had been little chance to do the therapy. Basically I regard the perforation area as artificial foramen, a foramen not belonging here.

In few cases, I tried Diaket out as root filling material with following fistulation. Treatment is also successful with Diaket, however, I mind that it doesn’t pour off the lentula the perfect way N2 does. It hardens as fast as N2, though. Root filling was followed by a possible apectomy/fistulation after 20 minutes. I also know surgeons who use either N2 or Diaket.

What does the N2 method comprise?
• No canal rinsing
• Use of the reamer as sole root canal instrument

Rubberdam for safety’s sake for manual manipulations only
• Use of the strongly antimicrobial N2 as root canal filling material (the powder contains five per cent formaldehyde, EU approval as medical device 6/1986)
• Root canal treatment in one appointment is the goal (no problem in vital teeth, in non-vital teeth with reservation – in the latter case definitely complete reaming during the same appointment). Alternatively in one appointment finished by “Scheroder Airation”. According to Sargenti, the “Scheroder Airation” comprises a wide treatment spectrum: pain prophylaxis is during root canal treatment of non-vital teeth in one appointment plus after overfilling of vital teeth roots, apart from that for pain therapy
• According to Sargenti, point condensation of the root filling is not necessary, however, it looks better on X-ray

What do you think about the frequently discussed ingredient formaldehyde: Systemic distribution in the body according to literature?
There is only an ambivalent answer to this question. The Block study with dogs as test animals circulates in literature. First of all, it has to be made clear that results from animal experiments cannot simply be adopted for humans due to different metabolisms. So formaldehyde features different half-lives in different animal species. In humans, half-life of formaldehyde amounts to 1 – 1.5 minutes. In an N2 court hearing in the US, the former leading US toxologist Brent stated that the results of the Block study had been misinterpreted. Due to the short half-life, formaldehyde had no longer bonded to marker C14. Correctly, the systemic distribution of C14 in the organs had been detected, however not for formaldehyde. At this point, I also wish to criticise laboratory tests (in vitro). An adoption of obtained results has to be judged skeptically as the enzymes of the living organism are missing.

Have you ever experienced intolerances or allergic reactions to N2 in your practice?
I never have seen an immediate or time-delayed allergic reaction although, to my knowledge, five of my patients, who have been provided with N2 root fillings, actually do suffer from formaldehyde allergy. Surely the (not verified) estimated number of unreported cases might have been much higher. As can be learned from literature, allergies against dental material do occur extremely rarely. In addition, self-reported cases do not necessarily stand up to scientific examinations.

There is a lot of criticism against N2. What do you think about this and what would you answer the critics?
Counter question should be whether the respective critic refers to literature or whether the argumentation is based on own practical experience. A handful of cases are not sufficient, though. Regarding literature, it has to be clarified whether a so-called “publication bias” does exist, meaning that disagreeable results are not even being published.

What do you think is the reason for the fact that the N2 method is accepted in other countries?
Despite of professorship concerns, N2 has been approved in the EU. Even Sweden has reaccepted the method in 2011 as in some publications, the established treatment has not been presented convincingly – and especially it could not have been proven that newer methods deliver better results. In Oral Surg Oral Med Oral Pathology 2002, 94 (6): 651 – 652, Figdor G. had recorded that endodontics have only achieved a modest progress over the last 100 years. This complies with the statement of N2 etc. in Int. Endod J. 2008, 41:51. Outcome of root canal treatment: systematic reviews of literature – Part 2 Influence of clinical factors”. As dental technology had progressed strongly within the last 40 – 50 years, a higher probability of success could have been expected. Endodontists, however, deny this non-increase stating that they are treating more risky endodonic cases now.

I’d like to add that the AES has in vain struggled to obtain N2 approval by the FDA (Food and Drug Association, responsible for approval of medical devices) for many years now. It is not a comfort for the local N2 users that so far also no other root canal filling material obtained an approval. It is shameful that hundreds of X-ray photos requested by the FDA could not be relocated by the FDA.

Is there any evidence of cancerogenity or mutagenicity from your point of view?
Cancerogenity or mutagenicity could not have been proved by now. However, formaldehyde has been classified as human carcinogenic some years ago, i.e. for pharyngeal tumor after consumption of a high dosage.

Like in many cases, the same rule must be obeyed: Toxicity depends on dosage. Sill the statement on formaldehyde of the German Federal Medical Association (Dr. Ärzteblatt 1987; 84, issue 5, 320 – 321) comprising that exceeding of a threshold value is the precondition for cancerogenity keeps valid.

What are your experiences with histological examinations after N2 treatment?
Blind studies should be done, which, to my knowledge, do not yet exist. Test arrangements, the kind of cuts, definition of normality and aberrations are important factors in histology – however, the different per cent of the histologically examined endo teeth are free from inflammation. And every colleague has the experience of false negative resp. false positive X-ray findings. Apart from that, evaluation of one or another X-ray picture, done at intervals of some months, often results in a different diagnosis.

Have their ever been complaints or discontent with N2 treatment from the patients’ side?
No.

What do you think about supposedly described parhesia or dysesthesia after N2 treatment?
I wrote on these topics in “Endodontie 4/1998: 523 – 536. Damage to the N. alveolares inferior by overfilling with root canal material”. I could refer to a similar article by Kockapan with his statement that the frequently reported nerve damages caused by N2 cannot be ascribed to the physiological characteristics of the material but to its worldwide use. Naturally, such incidents are only published with some years’ delay. Consequently, the use of N2 has strongly been decreasing for years, which cannot be only attributed to the statements of professorships but is also caused by the variety of new products. Each and every new technique and promoted root canal filling material on the healthcare market claims to offer a sophisticated product: respectively material for the patients’ and practitioners’ interest. Could you ever blame your colleagues for taking hold of the new products?

Have you ever observed bone or gingival necrosis after the use of N2?
I had to diagnose a gingival necrosis only once after following Sargenti’s proposal to put an N2-soaked stripe of tamponade into the gingival pocket.

Publications: