Endodontic irrigants
Gary Glassman discusses the use of irrigants

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

Additionally, the root canal system has a complex anatomy that consists of ramifications, isthmuses and cul-de-sacs that harbour organic tissue and bacterial contaminants (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 dentine smear layer, micro-organisms, and micro-toxins from the root canal system.

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.

In addition, Enterococcus facalis and Actinomyces prevention or treatment 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. Finally, E. facalis commonly expresses multidrug resistance, complicating treatment.

Therefore, a suitable irrigant and irrigant delivery system are essential for efficient irrigation and the success of endodontic treatment. Root canal irrigants must not only be effective for dissolution of the organic and inorganic 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.

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-canatal 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. 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. It has the unique ability to dissolve necrotic tissue and the organic components of the smear layer. It also kills sessile endodontic pathogens organised in a biofilm. There is as other root canal irrigant that can meet all these requirements, even with the use of methods such as lowering the pH, increasing the temperature, or adding surfactants to increase the wetting efficacy of the irrigant.

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. Calculifications 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. 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. These irrigants must be brought into direct contact with the entire canal-wall surfaces for effective action, particularly in the apical portions of small root canals.

The combination of NaOCl and EDTA has been used worldwide for antimetaplasia 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.\(^41\) NaOCl has a broad antimicrobial spectrum,\(^6\) including but not limited to E. faecalis. NaOCl is superior among irrigants, 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.\(^6\) 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.\(^4\) Manual irrigation includes positive-pressure irrigation,\(^9\) the plastic rotary F File (Plastic Endo),\(^49\) the Vibringe (Vibringe),\(^50\) the Rinsendo (Air Techniques),\(^51\) and the EndoActivator (DENTSPLY Tulsa Dental Specialties).\(^52\)

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.\(^9\)

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.\(^9\) Apical vapour lock also results in gas entrapment at the apical third.\(^9\) During irrigation, NaOCl reacts with organic tissue in the root canal system, and the resulting hydrolysis liberates abundant quantities of ammonia and carbon dioxide.\(^55\)

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,\(^9\) 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 polyvinylsloxane 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.\(^9\) Micro-CT scanning and histological tests conducted by Tay et al. have also confirmed the presence of apical vapour lock.\(^9\) 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 vapour lock may also explain why root canal systems have been unable to demonstrate a clean apical third in sealed root canals, as well as isthmuses and lateral canals, which irrigation system will effectively irrigate the apical third, as well as isthmuses and lateral canals, and in a safe manner that always prevented the thorough cleaning of the apical 3mm. It is critically important to determine for the patient’s safety have been shown to effectively disinfect root canals, operating 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.

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; we use 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 2-5mm 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.46,56 Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the pulsed or continuous 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 was initially clinically demonstrated4 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.” Therefore, Munoz4 demonstrated that passive ultrasonic irrigation (PUI) and EndoVac are more effective than NaOCl as a consequence of their microbubbly 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.56,99 Paiva found that after a supplementary instrumentation procedure using 5.1 NaOCl that 25 per cent of the samples produced positive cultures. Coheena’s study examining the efficacy of the EndoVac found no microbial growth either after post instrumentation irrigation or at the one-week obliteration appointment.

When questioning these different results one must remember that microbial hydrolysis via NaOCl is an equilibrium reaction. Hand demonstrated that a 50 per cent reduction of NaOCl concentration resulted in a 500 per cent 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 16mm long shaped to a #35 with a six per cent instrument equals 0.144 cc. Paiva described placing a 0.06 EndoVac Delivery Tip (ULTRADENT) at WL – 4mm during instrumentation and discussed using PUI with #15 Kfile at WL. Imaging in some of these cases NaOCl was injected into the canal; however, this could not have filled the apical four millimeters46 due to the apical vapour lock.

According to Munoz, the canal was most likely immediately filled with ultrasonically activated NaOCl for one minute46, but as just described - only about 0.014cc would have been effectively available for this exchange, water activating.

In contrast, the Apical Negative Pressure irrigation system protocol described by Coheena et al. approximately 2ml of NaOCl actively passes through the complete WL for one minute.99 The difference in volumetric exchange equals 2/0.14 = 14,200 per cent and likely explains the disinfection differential.

The plastic rotary F File

Although sonic or ultrasonic instrumentation is more effective at removing residual canals debris than rotary endodontic files are,48 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 files are that it is time-consuming to set up, unwilling 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 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 1.7mm exit aperture, and a syringe carrying irrigant. The handpiece is powered by a dental air compressor and has an irrigation speed of 6.2ml/min. 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.106,107

The EndoVac apical negative-pressure irrigation system consists of 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 canal 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 is connected via tubing to the 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.107

The ISO size 0.52mm diameter stainless-steel MicroCannula has four sets of three laser-cut, laterally positioned offset holes adjacent to its closed end, 100μ in diameter and spaced 100μ 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 55.04 or larger.

During irrigation, the Master Delivery Tip delivers irrigant to the pulp chamber and submerging off the excess irrigant to prevent overflowing. Both the MacroCannula and MicroCannula exert negative pressure that pulls fresh irrigation 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 1mm 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.47 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.108,109

In addition, with respect to complications, 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,110 passive ultrasonic,111 the F File,112 the manual-dynamic Maxi- Probe (DENTSPLY)106,113 and the Pressure Ultrasound114 and the EndoVac, only the EndoVac was capable of cleaning 100 per cent of the isthmus area.

Apart from being able to avoid air entrainment, the EndoVac system is also advantageous in its ability to deliver irrigants safely to working length without causing their undue extrusion into the periapex112 thereby avoiding NaOCl incidents. It is important to note that it is possible to create positive pressure in the pulp canal that 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,27 the cytotoxic effects of NaOCl on vital tissue are well established.115 The associated sequelae of NaOCl exposure have been reported to include threatening airway obstructions, facial disfigurement requiring multiple corrective surgical procedures, permanent permanent paresthesia, loss of facial muscle control, and - the least significant consequence - tooth loss.116

Although the actual aetiology of the NaOCl incident is still uncertain, based on the evidence from actual incidents and the lack of association of the associated tissue trauma, it would appear that an intravenous injection may be the cause. The EndoActivator extruded only about .014cc per minute in a vein close to the root apex through which extrusion of irrigant occurred over the root canal and the irrigant then found its way into the venous complex. This would require positive pressure apical irrigant 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.117

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

Safety is in order to compare the safety of endodontic 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.12 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 irrigated (NaOCl) extrusion from root canals and determined the extrusion site to be non-deleterious agarose gel.12 Significant 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 post-operative pain, edema, swelling, muscle control, and subjectively, when apical negative-pressure irrigation was performed (EndoVac) than with apical positive-pressure irrigation.118

Efficacy

Fig. 2 EndoVac set-up.
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.

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.

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.

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. 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. Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discolouration, and allergic reactions.

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 terminus. 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 microbubbles at the apical terminus 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. 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.

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).

About the author
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Endodontic dentistry in daily practice use (16,000 cases)

Dr. Robert Teeuwen - A Practitioner of Endo Techniques according to Sargenti

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

How did you get into contact with Dr. Sargent? I wanted to meet Dr. Sargent whilst on vacation in Switzerland in 1989. He gave me quite a short shrift at his doorstep. In the year 1990, it was Dr. Sargent 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 endodontic treatment 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).

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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 ump-teen 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, out of the 40 completed cases I was bestowed the title of “master-surgeon”.

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 “Schröder Airation” (= artefact distribution). 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 N2, however, I mind that it doesn’t pour off the lentulo the perfect way N2 does. It hardens as fast as N2, though. Root filling was followed by a meticulous 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 antimony-crobiol N2 as root canal filling material (the powder contains five per cent formaldehyde, EU approval as medical device 6/1998)
• 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 “Schröder Airation”. According to Sargenti, the “Schröder 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 toxicologist 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 not been detected, however no formaldehyde. At this point, I also wish to criticise laboratory tests (in vitro). An adoption of these results has to be judged sceptically as the enzymes of the living organism are missing.

Have you ever experienced intolerances or allergic reactions to N2 in your practice? I have never seen an immediate or time-delayed allergic reaction to N2, 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 critics refer to literature or whether the argumentation is based on own practical experience. A hand-ful 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 effectiveness has 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, Figdar G. had recorded that endodontic technology had progressed strongly over the last 100 years. This compiles with the statement of Ng et al. 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 has progressed strongly within the last 50 – 60 years, a higher probability of success could have been expected. Endodontists, however, deny this non-increase stating that they are treating more risky endodontic 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 required 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 proven by now. However, formaldehyde has been classified as human cancerogen 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. Still the statement on formaldehyde of the German Federal Medical Association (Dr. Ärzteblatt 1987; 84, issue 10: – 82112) comprising that exceeding of a threshold value is the precondition for cancerogenity keeps standing.

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 – also in the histology of the examined root ends are free from inflammation. And every colleague should discuss the experience of false negative resp. false positive X-ray findings. Apart from that, evaluation of one and the same 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 multiply described parahesia or dysesthesia after N2 treatment?
I wrote on these topics in “Endodontie 4/1998: 525 – 536. Damage to the N. alveolars inferior by overfilling with root canal material”. I could refer to a similar comment in his statement that the frequently reported nerve damages caused by N2 cannot be ascribed to the physical 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 Surgeons’ associations 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, respective material has 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:

Fig 7 Tool # 43 with incomplete root canal filling and apical lesion

Fig 8 X-ray control after 19 months, NAD

Fig 9 Product Shot