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 in 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).6,7

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 root canal system.8 Even with the use of rotary instrumentation, the tip, stainless steel 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.9

In addition, Enterococcus faecalis 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.10,11 Finally, E. faecalis commonly expresses multidrug resistance,12,13 complicating treatment.

Therefore, a suitable irrigant and irrigant delivery system are essential for efficient irrigation and the success of endodontic treatment.14 Root canal irrigants must not only be effective for dissolution of the organic and inorganic layer that consists of arborisations, isthmuses and cul-de-sacs that have not been removed during instrumentation. The ability to deliver irrigant to the root canal terminus in a safe manner without causing harm to the patient is as important as the efficacy of those irrigants.15

The irrigant that satisfies most of the requirements for a root canal irrigant is NaOCl.16 It has the unique ability to dissolve necrotic tissue and 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.

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.17

Calcifications 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.18,19 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.20,21 These irrigants must be brought in direct contact with the entire canal-wall surfaces for effective action.22,23,24 Particularly in the apical portions of small root canals.25

The combination of NaOCl and EDTA has been used worldwide for antiseptics 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 dem-onstrated in a study by Hand et al. comparing 2.5 and 5.25 per cent NaOCl. The higher concentration may also favour superior microbio-
al outcomes.41 NaOCl has a broad antimi-
erculidal spectrum,26 including but not limited to E. faecalis. NaOCl is superior among irrigat-
ing agents that dissolve organic matter. EDTA is a chelating agent 

that aids in smear layer removal and increases dentine permeabil-
ity,42,43 which will allow further ir-
rigation with NaOCl to penetrate deep into the dentinal tubules.46 

General safety precautions 

Regardless of which irrigant and irrigation system is employed, 

and particularly if an irrigant adjacent to the rubber dam on the tooth being isolated, a temporary sealing ma-

terial must be used prior to per-

forming the procedure to ensure a good rubber dam seal. It is also 

important to protect the patient’s eyes with safety glasses and pro-

tect clothing from irrigant splatter or spill. 

It is very important to note that while NaOCl has unique proper-
ties that satisfy most require-

ments for a root canal irrigant, it also exhibits tissue toxicity that 

can result in damage to the adja-
cent tissue, including nerve dam-

age should NaOCl incidents occur 
during canal irrigation. Further-

more, Salzgeber reported in the 

1970s that apical extrusion of an 

endodontic irrigant routinely oc-

curred in vivo.44 This highlights 

the importance of using devices 

and techniques that mini-
mise or prevent this. NaOCl 

incidents are discussed later in 

this article. 

Irrigant delivery systems 

Root canal irrigation systems 
can be divided into two catego-

ries: manual agitation techniques 

and machine-assisted agitation techniques.9 Manual irrigation 

includes positive-pressure irri-

gation, which is commonly per-

duced by a syringe and a side-

vented needle. Machine-assisted 

irrigation techniques include son-

ics and ultrasonics, as well as new-

er systems such as the Endo-

Vac (SybronEndo), which deliv-

ers apical negative-pressure ir-

rigation; the plastic rotary F File 

(Plastic Endo),16,27 the VibeRinge 

(VibeRing),28 the Rinsendo (Air 

Techniques),29 and the EndoActi-

vator (DENTSPLY Tulsa Dental 

Specialties).30 

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, par-

icularly to the apical third, and 

whether the irrigant is capable of debriding areas that could not be 

reached with mechanical instru-

mentation, such as lateral canals and isthmuses. When evaluating 

irrigation of the apical third, the 

phenomenon of apical vapour 

lock should be considered.30–32 

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 displace-

ment during instrumentation and final irrigation, thus preventing 

the flow of irrigant into the apical 

region and adequate debridement of the root canal system.30,31 Apical 

vapour lock also results in gas en-

trapment at the apical third. Dur-

ing irrigation, NaOCl reacts with 

organic tissue in the root canal 

system, and the resulting hydroly-

sis liberates abundant quantities of ammonia and carbon dioxide.32 

This gaseous mixture is 

trapped in the apical region and 

quickly forms a column of gas 

into which further fluid penetra-
tion is impossible. Extinction of 

instruments into this vapour lock 
does not reduce or remove the 
gas bubble,32 just as it does not 

enable adequate flow of irrigant. 

The phenomenon of apical va-

pour lock has been confirmed in 

studies in which roots were em-

bedded in a polyvinylsiloxane im-

pression material to restrict fluid 

flow through the apical foramen, 
simulating a close-ended chan-

nel. 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.30–32 

Micro-CT scanning and histo-

logical tests conducted by Tay et 

al. have also confirmed the pres-

nence of apical vapour lock.32 In 

fact, studies conducted without 

ensuring a close-ended channel 
cannot be regarded as conclusive 
on the efficacy of irrigants and the
Ultrasound - 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.

Studies have demonstrated that effective delivery of irrigants...
to the apical third can be enhanced by using ultrasonic and sonic devices that demonstrate acoustic micro-streaming and cavitation.44-46 Acoustic micro-streaming is defined as the movement of fluids along cell membranes, which occurs as a result of the time-varying acoustic field, with 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, introduced by Vita, has been clinically demonstrated 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.103, 104 Gondim et al. demonstrated that passive ultrasonic irrigation (PUI) and EndoVac are more effective than other irrigation methods on the apicocentric 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.105,106 Paiva found that after a supplementary irrigation procedure using PUI with NaOCl that 25% of the samples produced positive cultures. Cohena’s study examining the efficacy of the EndoVac found no microbial growth either after post instrumentation irrigation or at the one-week obturation appointment.

When questioning these divergent 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 life-time of an instrumented root canal 18mm long shaped to a #35 with a six per cent instrument equals 0.04 cc. Paiva described placement of a needle through the Master Delivery Tip (ULTRADENT) at WL - 4mm during instrumentation and discussed using PUI #15 Kife at WL - 1mm. Imaging showed NaOCl was injected into the canal; however, this could not have filled the apical four millimeters due to the apical vapour lock.

According to Munoz, the canal was most likely immediately filled with ultrasonically activated NaOCl for one minute, but as just described - only about .014cc would have been effectively available for this exchange reaction. In contrast, the Apical Negative Pressure protocol described by Cohena et al. approximately 2ml of NaOCl actively passes through the complete WL for one 92 minute.9 The difference in volumetric exchange equals 2/01 = 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 canal debris than rotary endodontic files,107 irrigation solutions are often unable to remove this debris en-dodontic 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 file design with a diamond abrasive embedded into a non-toxic polymer. The F File will remove dentinal wall debris and agitate the NaOCl without enlarging the canal further.

Pressure-alternation devices Rinsendo irrigates the canal using pressure– suction technology. Its components are a handpiece, a cannula with a 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.110,111

The EndoVac apical negative-pressure irrigation system has three components: the Master Delivery Tip, MicroCannula and MacroCannula. The Master Delivery Tip simultaneously delivers and evacuates the irrigant (Fig. 2). The MacroCannula is used to suction irrigant from the chamber with the mid- and coronal middle sections 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 and the evacuation hose 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.112

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

During irrigation, the Master Delivery Tip delivers irrigant to the pulp chamber and apically offsets the excess irrigant to prevent over-syringe. Both the MacroCannula and MicroCannula exert negative pressure that pulls fresh irrigant from the chamber, down the canal to the tip of the cannula, into the cannula, and out through the suction hose. Thus, a constant flow of fresh irrigant is delivered by negative pressure to working length. A recent study showed that the volume of irrigant delivered was significantly higher than the volume delivered by conventional syringe needle irrigation within the same period, and resulted in significantly more debris removal at 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.113 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.114,115

In addition, with respect to instrumentation, 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,116 passive ultrasonic,117 the F File,118 the manual-dynamic Maxi- Probe (DENTSPLY Rinn),119 the Pressure Ultrasonic120 and the EndoVac,121 only the EndoVac was capable of cleaning 100% 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 periapex122 thereby avoiding NaOCl incidents. It is important to note that it is possible to create positive pressure in the pulp canal and this is avoidable when 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

Although a devastating endodontic NaOCl incident is rare,123 the cytotoxic effects of NaOCl on vital tissue are well established.124 The associated sequelae of NaOCl exposure have been reported to include threatening airway obstructions,125 facial discoloration requiring multiple corrective surgical procedures,126 permanent palatal tissue loss and facial muscle control, and - the least significant consequence - tooth loss.127,128

Although the exact aetiology of the NaOCl incident is still uncertain, based on the evidence from actual incidents and the associated tissue trauma, it would appear that an intravenous injection may be the cause. The intravenous route may have introduced a widespread area of tissue trauma that is in contrast to the characteristics of NaOCl incident trauma reported by Flashner.129,130

This extensive trauma, and 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 had occurred as the irrigant then found its way into the venous complex. This would require positive pressure apical negative-pressure irrigation in a patient with a 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 ve

This does not imply that NaOCl can or should be excluded as an endodontic irrigant; in fact, its usefulness 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 different 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 irrigant (NaOCl) extrusion during ultrasonic instrumentation and demonstrated a wide range of non-toxic polymer. The F File will remove dentinal wall debris and agitate the NaOCl without enlarging the canal further.
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 apexes. In an in vivo study of 22 teeth by Siu and Baumgartner, less debris remained at 4mm 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.117

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

Microbial control
Hockett et al. tested the ability of apical negative pressure to remove a thick biofilm of E. Faecalis, finding that these specimens rendered negative cultures obtained within 48 hours, while those irrigated using traditional positive-pressure irrigation were positive at 48 hours.98

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.98 In a study comparing the use of apical positive-pressure irrigation and a triple antibiotic that has been utilised for pulpal regeneration/vasculogenesis 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.100 Using apical negative pressure and NaOCl also avoids the risk of drug resistance, tooth discoloration, and allergic reactions.101

Conclusion
Since the dawn of contemporary endodontics, dentists have been striving 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 NaCl 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.102 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.103

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 I. Grossman Study Club Award for academic and clinical proficiency. An 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
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

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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 16,488 endodontic treatments with N2 in permanent teeth from 7/1969 to 12/2005. My assistants made it to 10,436

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 endodontic 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 endodontic treatment of deciduous teeth.

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

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If not overfilled, a vital endodontic treatment with N2 never ends up in pain, including endodontic treatment of deciduous teeth.

Fig 1 1994: Xray control after 13 years, N2

Fig 2 1994: Teeth 16 reimplanted with existing paraeds

Fig 3 2007: Xray control after 24 years

Fig 4 2007: Xray control after 24 years

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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 endodontic treatment of deciduous teeth.
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 and demonstration of 30 completed cases I was bestowed the title of “mas- tership”.

My mentioning of more than 10,000 treatments does not nec- essarily 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 di- rectly 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 ob- served 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” (=artificial fistulation). In most of the cases, gangrenous teeth could also be treated in one ap- pointment. 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 apex- tomy/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 re- gard the perforation area as an artifi- cial 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 lentulo the perfect way N2 does. It hardens as fast as N2, though. Root filling was followed by a possible apeto- my/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 retriever as sole root canal instrument

Rubberdam for safety’s sake for manual manipulations only

• Use of the strongly anti-microbial 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 treat- ment spectrum: pain prophylax- is during root canal treatment of non-vital teeth in one ap- pointment 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 ac- cording to literature?

There is only an ambivalent an- swer 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 experi- ments cannot simply be adopt- ed for humans due to different metabolisms. So formaldehyde features different half-lives in different animal species. In hu- mans, half-life of formaldehyde amounts to 1 – 1.5 minutes. In an N2 court hearing in the US, the former leading US toxolo- gist 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 distribu- tion of C14 in the organs had been detected, however not for for- maldehyde. At this point, I also wish to criticise laboratory tests (in vitro). An adoption of these results has to be judged skepti- cally as the enzymes of the liv- ing organism are missing.

Have you ever experienced intolerances or allergic reac- tions to N2 in your practice?

I have never seen an immediate or time-delayed allergic reac- tion although, to my knowledge, five of my patients, who have been provided with N2 root fill- ings, actually do suffer from formal- dehyde allergy. Surely the (not verified) estimated num- ber of unreported cases might have been much higher. As can be learned from literature, al- lergies against dental material do occur extremely rarely. In addition, self-reported cases do not necessarily stand up to sci- entific 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 re- fers 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 disagree- able results are not even being published.

What do you think is the rea- son for the fact that the N2 method is accepted in other countries?

Despite of professorship con- cerns, N2 has been approved in the EU. Even Sweden has reaccepted the method in 2011 as in some publications, the es- tablished endodontic 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 Pa- thology 2002, 94 (6): 651 – 652, Figdor G. had recorded that en- dodontists have only achieved a modest progress over the last 100 years. This complies with the statement of NgY et al. in Int. Endoth 2008, 41:51 “Outcome of root canal treatment: system- atic reviews of literature – Part 2 Influence of clinical factors”. As dental technology had pro- gressed strongly within the last 40 – 50 years, a higher probabil- ity of success could have been expected. Endodontists, however, deny this non-increase stat- ing 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, respon- sible 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 ob- tained an approval. It is shameful that hundreds of X-ray pho- tos requested by the FDA could not be relocated by the FDA.

Is there any evidence of can- cerogenity or mutagenicity from your point of view? Cancerogenity or mutagenicity could not have been proven by now. However, formaldehyde has been classified as human cancerogene some years ago, i.e. for pharyngeal tumor after consumpion 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 (Dt. Ärzteblatt 1987; 84, issue 15; 8207 – 8211) concluding that exceeding of a threshold value is the precondition for cancerogenity keeps unestablished.

What are your experiences with histological examina- tions and the results?

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 – especially when per cent of the histologically examined endo teeth are free from inflammation. And every colleague who has the experience of false negative resp. false positive X-ray find- ings. 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 com- plaints or discontent with N2 treatment from the patients’ side?

No.

What do you think about mul- tiply described parahesia or dysesthesia after N2 treat- ment?

I wrote on these topics in “Endo- dontie 4/1998: 523 – 536; Dam- age to the N. alveolaris inferior by overfilling with root canal material”. I could refer to a sim- ilar article by Kockapan with 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 de- creasing for years, which cannot not only be attributed to the statements of some author- ships but is also caused by the variability of new products. Each and every new technique and promoted root canal filling ma- terial on the healthcare market claims to offer a sophisticated procedure, respectively material “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 ne- crosis only once after following Sargenti’s proposal to put an N2-soaked stripe of tamponade into the gingival pocket.

Publications:

Schädigung des Nervus alveo- laris inferior durch überfül- ltes Wurzelkanalfüllmaterial.. Endodontie #4; 1999: 525-536; Damaged N. alveolaris inferior through overfilling with root canal material

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