

# Ozone in endodontics

Alan Holland discusses using ozone in endodontic therapy

## CPD Aims and objections

This clinical article aims to discuss using ozone in endodontics. Providing an overview of ozone before looking at the effect on bacteria and how it can be used in endodontic therapy.

## Expected outcomes

Correctly answering the questions on page 33, worth one hour of verifiable CPD, will demonstrate that you understand the benefits of using ozone in endodontic treatment.



There are three aspects to the success of endodontics:

- The mechanical preparation
- Chemical disinfection
- Three-dimensional obturation.

Regardless of what is used to obturate the canal, or the technique used to prepare the canals, the ultimate long-term success of the procedure depends on the cleaning and disinfection of the root canal system.

Since the work done by Hess in the 1920s, dentistry has been aware of the complexity of the root canal system, which has to be cleaned using both mechanical and chemical agents (Hess, Zurcher, 1925). The limitation of the instruments due to the small size of the canals and the difficulty of negotiating all the spurs, isthmi, ribbons and lateral canals has led to a bewildering explosion of different types of rotary systems intent on being the most effective mechanical aid.

The most significant factor in obtaining maximum results in root canal irrigation is the diameter of the canals (Ram, 1977). The apical diameter one millimeter from the apex prepared to a circular cross section in 98% of molars would be ISO 60, if the instrumentation allowed (Weiger, Bartha et al, 2006; Kerekes, Tronstad, 1988; Card, Sigursson et al,

2002). The most commonly used disinfectant solutions employed to irrigate and chemically clean root canals are sodium hypochlorite and chlorhexidine.

Hypochlorite is acutely operator sensitive, requiring careful application during root canal cleaning to prevent inoculation through the apex into bone or soft tissue, which can cause alarming and destructive oedema, pain and tissue damage (Huth, Jacob et al, 2006). The application in narrow canals of a potentially destructive and harmful solution that, with the majority of current techniques, produces an inadequate size for irrigation will lead to a flaw in the disinfection regime required to ensure a successful root canal treatment.

The limitations of current instrumentation for debridement of root canals – and the potentially harmful effects of the chemical cleaning agents and difficulty of their application to the site of bacterial biofilm contamination – means that the cleaning of complex root canal systems is compromised, leading to potential failure. The use of safe and effective bactericidal concentrations of a sterilizing gaseous agent, which will perfuse otherwise compromised and inadequately prepared complex root canal systems using current techniques, has to be an exciting recent application in root canal therapy (Huth, Quirling et al, 2009).

## Ozone: an overview

In nature, ozone is created by a combination of oxygen in the air under the influence of such factors as ultraviolet radiation (from the sun) and electrical discharges (lightning). It is also created in areas where there is intense physical stress on water (such as waterfalls and ocean waves crashing onto rocks)

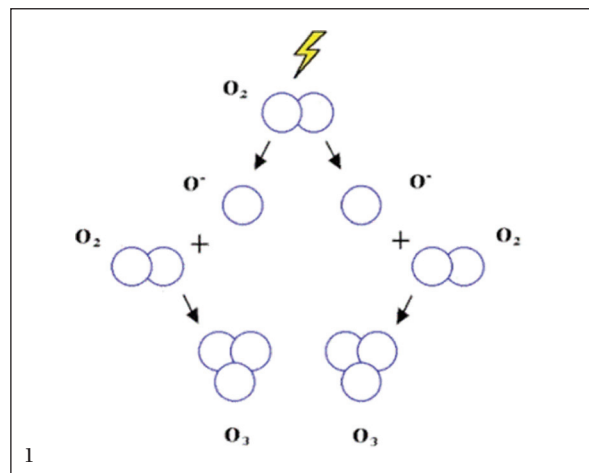


Figure 1: An electrical discharge splits an oxygen molecule into two oxygen atoms (electrical discharge is also referred to as corona discharge). These unstable oxygen atoms combine with other oxygen molecules. This combination forms ozone

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Alan has taken endodontic referrals since 1991 and was the first private practitioner to use an operating microscope in 1992. He has lectured nationally and internationally, authored several articles, and been interviewed on radio and television. A former hands-on tutor at the Bristol Dental Hospital he has run many practical endodontic courses throughout the United Kingdom. In 1999 he was accepted on to the GDC Specialist Endodontic register and now runs regular seminars at the Bristol Endodontic Clinic.

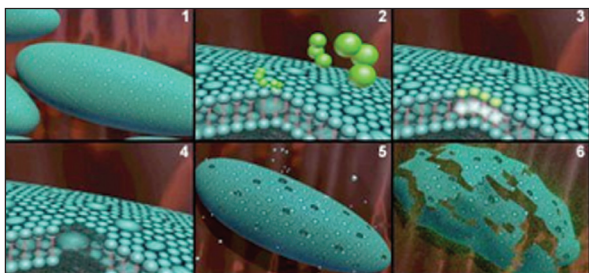


Figure 2: A healthy bacillus bacteria. Attacked by the ozone causes multiple cell wall perforations with rapid cell lysis

where natural concentrations of ozone in the air can reach levels of up to 0.05ppm, a point when its characteristic odor may be detected. Ozone works as a natural bactericide, inactivating bacteria, viruses, fungi, yeast and protozoa.

Ozone is a gaseous, energized form of oxygen with the chemical formula  $O_3$ . It is unstable and dissociates readily back into oxygen ( $O_2$ ), thus liberating so-called singlet oxygen ( $O_1$ ), which is a strong oxidizing agent. It is this particular reactivity that provides the starting point for ozone's therapeutic effects on the body.

The different modes of action on a living organism are now well understood and involve the production of ozone generated peroxides. It is these that are responsible for the remarkable bactericidal and fungicidal effects. The virus inactivation takes place in a similar way and is enhanced by a peroxide intolerance of virus infected weakened cells.

### Effect of ozone on bacteria

Peroxides are powerful free radicals that invoke an immediate oxidative stress response, encouraging activation of the innate immune system to promote free radical scavenging.

Ozone has the advantage over other free radical producing agents in that normal human cells are protected from the oxidative stress effects of ozone if used in correct amounts, and, in addition, ozone appears to promote a stimulation and activation of the enzymes involved in peroxide and free radical scavenging (glutathione peroxidase, catalase and superoxide dismutase), thus enhancing immune responsiveness and a more rapid healing response.

Ozone can also be shown to have a measurable benefit on the uptake and utilization of oxygen through improved glycolysis in red blood cells, an improved blood flow and stimulation and activation of mitochondrial respiration and other metabolic pathways (Nogales, Ferrari et al, 2008). Ozone inactivates bacteria viruses by cell lysis (Nagayoshi, Fukuizumi et al, 2004). In contrast, sodium hypochlorite (2.5-5.25% concentrations) requires diffusion into the cell where it then inactivates enzymes, causing cell destruction.

Ozone has been used since 1885 in medicine (Kenworthy, 1885), to treat an extensive variety of conditions over 100 years (Stubinger, Sader et al, 2006). This is based on the fact that some disease is caused by a lack of oxygen at the cellular level. Ozone acts as a super-oxygenator, bringing oxygen to tissues and assisting the body in its natural healing process. Ozone is organic and unlike many other substances such as chlorine, a known carcinogen, it leaves no chemical trail.

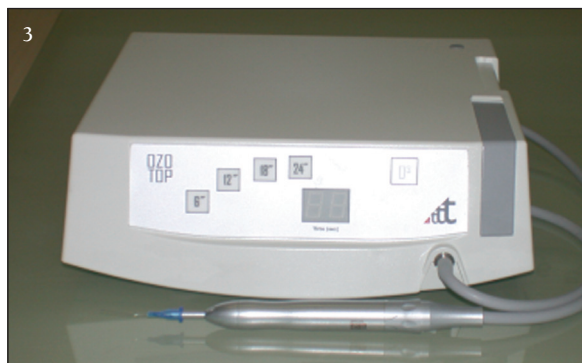


Figure 3: OzoTop chair-side unit



Figure 4: Root canal treatment with ozone



Figure 5: Six months later



Figure 6: Root canal treatment with ozone

Figure 7: Four months later

Figure 8: Root canal treatment with ozone



Figure 9: Four months later



Figure 10: Root canal treatment with ozone



Figure 11: Three months later – complete healing



There are several ways of using ozone medically – it may be infused with the blood, and has been advocated to sterilize blood used for transfusion to eliminate bacteria and viruses, preventing HIV cross infection (Baggs, 1993). There are bagging techniques for limbs and various sufflation techniques in orthopedics. In addition, there are ozonated oils and ozonated water for wounds and burns.

Ozone is also used extensively in water treatment plants gradually replacing chlorine. It is important to remember that the reason for this is that, when used in the correct amounts, ozone is safe, non-toxic and leaves no chemical residues. Due

to its short half-life, it quickly reverts back to oxygen. Many other substances, such as chlorine, have many known side effects and carcinogenic properties. In addition to dentistry, it is being utilized in swimming pools, fish farming (Wietz, Hall et al, 2009), food preparation, bottling plants, hand dryers, air purification, and medicine.

## Ozone in dentistry

In dentistry, we can look at ozone as a chairside disinfectant for virtually every application.

It is important to realize that we look at ozone as a synergistic part of the treatment, eliminating bacteria and oxygenating the site. Bacteria are the cause of many problems in dentistry and so to have something as powerful as ozone at hand to effectively eliminate the causative agent for most dental infections is an exciting, safe and effective tool.

## The OzoTop

The OzoTop is a free-flow ozone delivery system using a corona discharge. It is a compact, easy to use tabletop unit. Due to the delivery system of the OzoTop, root canals and periodontal pockets can be penetrated easily. The system may be used in all cases where point of placement disinfection is needed, including:

- Periodontology
- Endodontology
- Restorative
- Implantology
- Aphthous ulcers/herpes
- Gerodontology (dentures)
- Impression materials.

The system utilizes ambient air, which is filtered and dried before passing over a ceramic plate where a high voltage is applied and ozone is produced. Ozone is applied at six, 12, 18, 24 seconds, depending on which treatment is required. High volume suction is required as this is an open system.

## Other systems

The application of ozone in the oral cavity in a safe and controlled fashion has been a challenge for the manufacturers. Other types of machine have been large, bulky, closed systems, requiring the point of application to be enclosed and sealed due to the higher levels of ozone released during application.

The size and constraints also limit the application because of the requirement to have the area being treated sealed and very high suction under negative pressure incorporated to remove the ozone produced. These earlier systems required periods of rest to prevent overheating and may be more expensive to maintain and service.

Nevertheless, the pioneering work to bring ozone to the chairside has been invaluable in encouraging further developments into easier and more effective ozone generators, which allow a wider range of applications in dentistry. One open system using glass tube applicators and cold plasma ozone production with varying doses of ozone may require more patient visits.

There is extensive research following the use of the original closed type of machine to confirm that it can arrest caries, which will subsequently resolve certain carious lesions very

successfully with re-mineralization gels (Baysan, Lynch, 2007).

As a pioneer in the field, it has encouraged the development of the newer technology of free-flowing ozone using the OzoTop, which builds on the initial success by taking it forward to a more operator-friendly, chairside unit, broadening the safe application to include treatment of multiple dental pathologies.

## OzoTop safety

Values indicate that the OzoTop device is safe even in conditions where the patient inhales all the ozone produced by the device, which is practically impossible as much is dissipated into the atmosphere (Bocci, Borrelli et al, 2009).

Due to the analogy to environmental values, ozone generators are characterized with parts per million (ppm) value, which is not sufficient to define the dose. The OzoTop is designed to produce a constant amount of ozone per time unit.

- Ozone is measured in either mg/l or in ppm
- OzoTop production is 140ppm@ 2 l/min, which equates to 0.3mg @ 2 l/min
- This equates to  $280 \text{ mg/m}^3 \times 0.002 \text{ m}^3/\text{min} = 0.56 \text{ mg/min} = 33.6 \text{ mg/hour}$ .

Ozone efficiency is obtained by the contact of the ozone flow within the treatment area. The residual ozone must be removed from the mouth with suction. The suction then has two effects. By adding air, the ozone will be diluted, thus decreasing the ozone concentration in the buccal cavity. A medium suction (ISO10637, dental volume suction system) evacuates up to 90 l/min and the OzoTop production reaches 140ppm at 2 l/min after dilution, so the concentration level is  $140\text{ppm}/45=1.5\text{ppm}$ .

Time	6 secs	12 secs	18 secs	24 secs
Tip	OzoTip Coro	OzoTip Coro	OzoTip Perio	OzoTip Endo
Volume	1 l/min	1 l/min	0.8 l/min	0.4 l/min
Dose	0.056 mg	0.112mg	0.168mg	0.224mg

Safety regulations for workers allow 0.3ppm for 15 minutes. Breathing normally (5L/min) the total amount of ozone in the lungs would be 0.3ppm (0.6 mg/m<sup>3</sup>).

Safety regulations for user environment allow 0.1ppm for eight hours. In a dental office of 10m<sup>3</sup>, the amount of ozone would be 0.1ppm (0.2 mg/m<sup>3</sup>) or 2mg of ozone

## Ozone in endodontics

In my opinion, ozone gas administered to the area of treatment with accuracy and precision in complete safety by a compact, simple and stylish machine is one of the most exciting developments to be introduced into endodontic therapy recently.

The free-flowing ozone generator has now been in use in my specialist endodontic practice for over 18 months. We achieve very positive results for disinfecting root canals as well as its application in the treatment of soft tissue lesions such as herpes labialis, and aphthous ulcers (Stoll, Veanne et al, 2008).

Patients report little sensitivity, post-operative complications or discomfort following endodontic therapy, which includes ozone perfusion. During the last 12 months of use, radiographic reassessment shows significant and accelerated healing in many cases that display large, chronic apical infections. Ozone also eliminates the distinctive anaerobic odor associated with some chronically infected teeth.

A standardized hybrid technique for preparation of root canals is used with initial location of the canals and exploration using stainless steel K-files and Hedstrom files. This is followed by coronal pre-flaring, using the Tri-Ni-Ti system of nickel titanium rotary .04 or .02 taper carried to the working length. Apical diameter, often the forgotten dimension in root canal therapy (Card, Sigursson et al, 2002), is then identified and precisely determined using the new LSX lightspeed nickel titanium rotary files (Thompson, Dummer, 1997). Mechanical debridement of the root canal, using whichever system is favored, remains the method of choice for gross removal of necrotic debris, pulpal tissue, and infected dentin.

During the cleaning regime, we use a combination of ultrasonically-agitated and heated sodium hypochlorite, alternated with EDTA (Smear Clear), and Sterilox to chemically clean the canals. This standard procedure used for the last six years produces a very high success rate in excess of 95%.

We have added the use of ozone over the last 12 months as the final medication to eliminate any residual bacteria, which may remain in inaccessible anatomical areas or within the dentinal tubules themselves. After final drying of the canals prior to obturation, ozone gas produced by the OzoTop is introduced directly into the root canal to within 3mm of the apex using a slow in and out movement of the flexible cannula for 24 seconds in each root canal, as recommended by the manufacturer.

Surface tension of the chemical solutions (even with ultrasonic activation) may well be a factor in the incomplete cleaning of some canals, whereas there is no such restriction using a gas such as ozone that will flow into any available space or be absorbed into solution.

High volume suction held close to the isolated tooth prevents any dissemination of ozone into the atmosphere, avoiding the potential for inhalation by either the patient or operator (Millar, Hodson, 2007). Often, teeth heavily infected with anaerobic bacteria have a distinctive unpleasant odor that appears to be eliminated following the application of ozone.

The walls of the canals are coated with AH+ cement and, using a chloroform dip technique with ultrasonically softened master cone with both lateral and vertical condensation, the canals are effectively obturated.

The majority of patients seldom complain after 24-hours of anything other than mild discomfort and the radiographic recalls often show rapid healing of large apical areas within three to six months (Figures 4-11). This may be due to the stimulation of an antioxidant response being activated by the ozone, which releases free radicals such as peroxides, as well as the potent bactericidal and fungicidal disinfection of the canals (Stubinger, Sader et al, 2006).

## Conclusion

I have no hesitation in recommending the use of ozone and the OzoTop generator to speed up the healing process, reduce post-operative complications and add a further enhancement to our endodontic armamentarium to improve the success rate of endodontic treatment. In fact, I now feel uncomfortable

if I do not use the OzoTop as part of my treatment regime.

Further research (Azarpazhoo and Limeback, 2008) into this exciting adjunct to root canal therapy in particular, but also in the wider application in periodontics, implantology and oral surgery as well as the adopted treatment for caries (Baysan, Lynch, 2007), is indicated. **EP**

## References

- Azarpazhoo A, Limeback H (2008) The application of ozone in dentistry: a systematic review of the literature. *Journal of Dentistry* **36**(2): 104-16
- Baggs, AC (1993) Are worry-free transfusions just a whiff of ozone away? *Canadian Medical Association Journal* 1159
- Baysan A and Lynch E (2007) Clinical reversal of root caries using ozone: six month results. *American Journal of Dentistry* **20**(4): 203-8
- Bocci V, Borrelli E, et al (2009) The ozone paradox: ozone is a strong oxidant as well as a medical drug. *Med Rs Rev* **29**(4): 646-82
- Card SJ, Sigursson A, et al (2002) The effectiveness of increased apical enlargement in Reducing Intracanal Bacteria. *J Endodontics* **28**(11): 779-83
- Hess W, Zurcher E (1925) *The anatomy of the root canals of the teeth of the permanent dentition and the anatomy of the root canals of the deciduous dentition and the first permanent molars*. New York: William Wood and Co
- Huth K, Quirling M, et al (2009) Effectiveness of ozone against endodontopathogenic micro-organisms in a root canal biofilm model. *Int Endod J* **42**(1)
- Huth KC, Jacob FM, et al (2006) Effect of ozone on oral cells compared with established antimicrobials. *European Journal of Oral Science* **114**(5): 435-40
- Kenworthy CJ (1885) *Ozone*. Florida Medical Association
- Millar B, Hodson N (2007) Assessment of the safety of two ozone delivery devices. *Journal of Dentistry* **35**(3): 195-200
- Nagayoshi M, Fukuizumi T, et al (2004) Efficacy of ozone on survival and permeability of oral micro-organisms. *Oral Microbiology and Immunology* **19**(4): 240-6
- Nogales CG, Ferrari PH, et al (2008) Ozone therapy in medicine and dentistry. *Journal of Contemporary Dental Practice* **9**(4): 75-84
- Ram Z (1977) Effectiveness of root canal instrumentation. *Oral Surgery, Oral Medicine, Oral Pathology* **44**(3): 306-9
- Stoll R, Veanne L, et al (2008) The disinfecting effect of ozonised oxygen in an infected root canal: an in vitro study. *Quintessence International* **39**(3): 231-6
- Stubinger S, Sader R, et al (2006) The use of ozone in dentistry and maxillofacial surgery: a review. *Quintessence International* **37**(5): 353-9
- Thompson SA, Dummer PMH (1997) Shaping ability of Lightspeed rotary nickel-titanium instruments in simulated root canals: part 1. *J Endodontics* **23**: 698-702
- Weiger R, Bartha T, et al (2006) A clinical method to determine the optimal apical preparation: part 1. *Oral surgery, oral medicine, oral pathology, oral radiology, and endodontics* **102** (5): 686-691
- Wietz M, Hall M, et al (2009) Effects of seawater ozonation on biofilm development in aquaculture tanks. *Syst Appl Microbiol* **32**(4): 266-77

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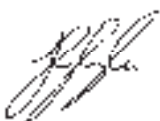
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