Title: Basics of Ozone In Dentistry
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1. Introduction to Ozone

Ozone (O_3) is an unstable molecule comprised of three oxygen atoms that naturally degrade back into pure atmospheric oxygen (O_2). Ozone is naturally produced in the earth's atmosphere through the molecular action between O_2 and Solar UV radiation in the stratosphere. Ozone can be from natural sources or a man-made product. Ozone has been successfully used for many years in medicine and dentistry.

In the mid 1800's, the first ozone generator was created and the first medical paper detailing ozone's use for blood purification was published. In the late 19th/early 20th century, doctors used ozone to sterilize traumatic wounds and manage acute infections, even during WWI. During this time, ozone therapy became an accepted alternative medical modality in the US. In 1935, Dr. Fisch was the first dentist that incorporated ozonated water into clinical practice. By the late 20th century, over 16 independent nations accepted ozone into standard medical practice.

Modern day ozone can be produced for clinical applications in dentistry and medicine via gas, water or oil. Ozone is known to have numerous effects on the human body, including bioenergetic, biosynthetic, anti-bacterial, anti-viral, anti-fungal, analgesic, anti-hypoxic, and detoxifying properties. Ozone also has a medicinal impact that speeds up blood flow and aids wound healing.

Ozonated glycerin is an emerging ozone delivery method for oral tissues. It has potential benefits such as prolonged contact and better adherence to the treatment site allowing sustained biological activity. Although direct clinical evidence specific to ozonated glycerin is still developing, its proposed applications are supported by the broader literature on ozone therapy, ozonated oils, and ozone gels.

Ozone is effective against antibiotic-resistant bacteria and becomes even more potent in acidic, fluid environments. Its clinical utility is derived from its powerful oxidative potential, which generates free radicals that destroy the cellular walls and cytoplasmic membranes of microflora by damaging structural glycolipids and glycoproteins. This action compromises cell permeability and disrupts vital enzymatic control systems, leading to immediate cell death. This process is highly selective in that human cells remain completely safe due to their advanced, protective antioxidant defense systems. Some common oral pathogens that ozone has been useful for, but are not limited to, include *Streptococcus mutants, Lactobacillus acidofilus, Enterococcus faecalis, Streptococcus sobrinus, Porphyromonas gingivalis, Tannerella forsythia, Parvimonas micra, Fusobacterium nucleatum, Campylobacter sputorum, Campylobacter gracilis, Peptostreptococcus micros, Psudomonas aeruginosa, Aggregatibacter actinomycetemcomitans, Eikenella corrodens, Helicobacter pylori, Candida albicans, Candida glabrata* and *Herpes* viruses.

Today, ozone use in dentistry has expanded. Currently, ozone has applications in multiple fields of dentistry such as Oral Surgery, Periodontics, Endodontics, Implantology, TMJ Therapy, Caries Management, Head and Neck Oncology and more.

2. Periodontics and Dental Hygiene

Ozone can be applied for treatment of many phases of periodontal and gingival inflammation. Ozone has unique traits including its capacity to destroy microbes, ability to neutralize bacterial toxins or biomolecule precursors, and its promotion of tissue renewal. Ozone has also been shown to modulate inflammatory mediators, improve local oxygen metabolism, and stimulate fibroblast activity, potentially enhancing periodontal tissue repair and reducing post-treatment inflammation. Some studies have reported improvements in clinical attachment levels, bleeding indices, and pocket depth reduction when ozone-based therapies are used alongside conventional periodontal treatment.

Research confirms that ozone has substantial antimicrobial efficacy against common periodontal pathogens and *Candida* species. Ozone displays high bactericidal action against aggressive periodontal pathogens. This pathogen reduction directly correlates with improved clinical outcomes in patients suffering from thrush and periodontal infections.

Non-Surgical Treatments

Clinical reviews show improvements in non-surgical treatment outcomes for periodontitis when ozone is used alongside traditional scaling and root planing (SRP). Studies demonstrate improvements in clinical attachment levels and probing depths in gingival tissues. While some data indicates the results are statistically comparable to photobiomodulation, chlorhexidine (CHX), or photodynamic therapy, ozone consistently outperforms traditional SRP therapies that lack adjunctive disinfection in terms of biological markers, inflammatory reduction, and microbiological health.

For periodontal patients managing type 2 diabetes, a combination protocol involving gaseous ozone and ozonated water rinses alongside traditional SRP has yielded improvements in clinical presentation, localized inflammatory biomarkers, and glycated hemoglobin (HbA1C) levels. In long-term evaluations spanning up to 12 months, patients treated with ozone exhibited superior enhancements in clinical attachment levels and reduced probing depths.

Clinical Uses for Dental Hygienists

At-Home Care

Dental hygienists can instruct periodontal patients to perform weekly at-home maintenance by irrigating periodontal pockets with ozonated oil via a blunt-tipped 25-gauge needle.

Pre-Procedural and Halitosis Management

Rinsing with ozonated water prior to a dental appointment can help disinfect the oral cavity. It can also serve as an effective home remedy to eliminate oral malodor.

Ultrasonic and Pocket Irrigation

Delivering ozone-infused water into affected areas both before and after therapies like subgingival pocket curettage or scaling and root planing minimizes the systemic and localized burden of pathogenic microorganisms.

Ozonated Glyerin

Ozonated glycerin may serve as a useful adjunct following scaling and root planing by helping reduce bacterial load within periodontal pockets while supporting local healing.

3. Caries Management and Hard Tissue Preservation

Ozone therapy is heavily researched as a conservative, minimally invasive tool to control dental caries due to its ability to alter the biochemistry of decay and eliminate acid-producing microflora.

Biochemical Reversal of Decay

During the decay process, acidogenic bacteria produce pyruvic acid, which is the strongest acid driving hard tissue demineralization. Ozone chemically decarboxylates pyruvic acid, turning it into acetic acid. Because acetic acid has a significantly weaker acidity profile, this reaction raises the localized oral pH, creating an alkaline environment that favors tooth remineralization. This biochemical transformation is complemented by microstructural benefits. Research has found that applying ozone gas to enamel for 40 to 50 seconds significantly enhances enamel microhardness while achieving a remineralization success rate between 96.82% and 97.38%.

Synergistic Remineralization

When paired with topical remineralizing therapies, ozone helps halt or reverse early, non-cavitated lesions. A trial with 92 participants found that combining a nano-hydroxyapatite gel with ozone therapy yielded the highest success in remineralizing approximal initial carious enamel. In addition, the study established that applying gaseous ozone prior to the placement of Aegis fissure sealant over non-cavitated early decay triggered the highest degree of remineralization and resulted in superior 12-month clinical retention compared to sealants used alone.

Fissure Sealant Comparison

Another study evaluated 50 patients to compare gaseous ozone directly against traditional pit and fissure sealants on active, non-cavitated occlusal lesions in first permanent molars. After a 12-month follow-up, ozone therapy was determined to be equally as effective as the mechanical sealants.

Clinical Limitations on Advanced Decay

Despite excellent laboratory data, overall clinical evidence regarding routine caries management varies. A systematic review published by the Cochrane Library in 2004 concluded that there is insufficient high-quality clinical evidence to prove that ozone consistently halts or reverses decay. One finding utilized a split-mouth design to evaluate occlusal decay in primary molars and found that neither ozone nor fluoride varnish could stop the progression of structurally cavitated lesions. Similarly, another study practiced stepwise excavation on young permanent molars and discovered that ozone gas exposure failed to improve or alter the baseline color or structural consistency of the deep dentin layer.

Bacterial Destruction

Applying ozone directly to carious anatomy can reduce the volume of cariogenic microflora and stops their metabolic actions, preventing further structural destruction. Research on a group of 40 children with deep permanent molar decay into dentin were evaluated before and after a 120-second ozone treatment or a 60-second rinse with 2% chlorhexidine (CHX). While both protocols dramatically lowered Streptococcus mutans and Lactobacillus sp. colonies, CHX demonstrated a statistically superior reduction in Lactobacillus sp. compared to ozone. Conversely, a different study determined that ozone's antibacterial performance against residual microbes left behind by incomplete decay removal was entirely equal to a 2% CHX solution.

Treating Dentin Hypersensitivity

Ozone therapy can provide rapid relief from dentin hypersensitivity. It achieves this by eliminating bacterial pathogens inside exposed dentinal tubules and modifying localized nerve responses. Additionally, ozone pre-treatments prepare the exposed tubules to accept minerals and subsequent sealing, accelerating the sealing process when used alongside remineralizing pastes.

Ozone may be delivered in several forms for the management of hypersensitivity, including gaseous ozone, ozonated water, and ozone-infused oils or gels. Gaseous ozone is the most extensively studied modality. It is typically applied directly to exposed dentin using a sealed delivery system for approximately 10-60 seconds, but it depends on the device and treatment protocol. Following ozone application, remineralizing agents containing calcium, phosphate, fluoride, nano-hydroxyapatite, or casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) are often applied to promote dentinal tubule occlusion.

Ozone is believed to enhance mineral uptake by oxidizing organic components within exposed dentinal tubules, reducing surface contamination, and increasing dentin permeability. This process may facilitate deeper penetration of calcium, phosphate, and other remineralizing ions into the dentinal tubules. This can promote the formation of mineral precipitates that physically occlude the tubules and reduce fluid movement. Since the hydrodynamic theory attributes dentin hypersensitivity to fluid shifts within open dentinal tubules, enhanced tubule occlusion may result in both immediate and sustained reductions in sensitivity. Studies have suggested that ozone treatment followed by remineralization therapy can produce greater reductions in hypersensitivity than remineralizing agents alone, supporting the concept that ozone functions not only as an antimicrobial agent but also as a facilitator of mineral deposition and dentin repair. While treatment protocols vary among studies, ozone therapy is generally used as an adjunctive treatment rather than a stand-alone therapy. Repeated applications may be recommended in cases of persistent sensitivity.

4. Orthodontics

Bonding and Adhesion

A primary concern in orthodontics is ensuring that pre-treatments do not compromise the bond strength of brackets or sealants. Modern research demonstrates that utilizing gaseous ozone on the enamel surface does not cause microleakage or degrade the immediate bonding capacity of dental sealants. Clinicians can reliably disinfect enamel surfaces before applying sealants without decreasing material performance.

Adhesive System Neutrality

Similarly, a different study evaluated the impact of ozone pre-treatment on the shear bond strength and subsequent failure modes of self-etch and etch-and-rinse adhesive systems on enamel. The data confirmed that prior ozone gas application did not alter the shear bond strength values for either adhesive type.

Disinfecting Clear Aligners

Ozone's ability to decontaminate clear aligners was very successful and had results comparable to chlorhexidine. This could suggest possible use for manufacturing and elastomeric impressions while equaling or outperforming other disinfectant solutions without altering its material properties.

5. TMJ and Orofacial Pain

Ozone's notable analgesic and anti-inflammatory characteristics make it an emerging option for symptom relief. In clinical practice, its capacity to mitigate inflammation and block pain pathways helps alleviate the chronic or acute physical discomfort experienced by individuals suffering from temporomandibular disorders (TMD).

One study on ozone and TMJ disorders comparing NSAIDs vs. Ozone injections into superior joint space found that ozone injection contributed to either significant improvement or complete recovery of internal derangement of the TMJ in 87% of the patients.

Nerve Regeneration

A study performed on rats showed promising potential for nerve regeneration. Intra-peritoneal insufflation of gaseous ozone helped improve healing outcomes compared to other modalities such as LLLT (low-level laser therapy) and controls. Further research is needed in humans with regard to nerve regeneration.

6. Endodontics

Ozone therapy is highly valued in endodontics for its robust antimicrobial actions against the persistent pathogens responsible for pulpal and periapical infections. Mechanical root canal preparation often leaves hidden microbes behind. However, ozone can help penetrate deeply into the dentinal tubules to destroy lingering bacteria. Gaseous ozone and ozonated water rinses display excellent oxidative destruction against highly resilient endodontic strains, specifically *Enterococcus faecalis* and *Candida albicans*. Clinical standards recommend incorporating ozone therapy as a powerful disinfectant adjunct to enhance traditional chemical irrigation protocols rather than using it as a standalone replacement. Ozonated glycerin may potentially be used as an adjunctive intra-canal medicament or as a supplemental irrigant delivery system. This can allow for prolonged exposure of antimicrobial compounds to infected dentinal surfaces.

However, in an in vivo study of infected human root canals, the authors showed that the application of gaseous ozone may not be sufficient to completely remove *E. faecalis*. Although ozone has been considered to be a less toxic option, it has been shown to only penetrate up to .3 mm into dentinal tubules, leaving 2-3 mm untouched and unable to be completely disinfected. Root canals need to be completely sterilized in order to be successful.

7. Oral Surgery, Wound Healing and Infection Control

Ozone acts as a biological booster that enhances the surgical environment by improving localized blood flow, tissue oxygenation and other benefits. Ozone has been shown to stimulate angiogenesis, increase local oxygen utilization, and promote fibroblast proliferation and collagen synthesis. These effects may contribute to improved soft tissue healing, reduced postoperative discomfort, and a lower risk of secondary infection. Ozone has shown beneficial effects compared to controls for lower pain scores, accelerated healing and lower incidence of post-op complications for the management of complications following extractions. These fields included dry socket, osteonecrosis of the jaw (ONJ), palatal grafts, gingival surgery and removal of pigmentation with laser.

Prophylactic Use

Ozone gas application used prophylactically before and immediately after surgery can help avoid post-extraction complications such as edema, trismus, dry socket, bone necrosis, granulation tissue, raised skin temperature and hematoma formation. Ozone therapy has also shown beneficial effects on wound healing by improving oxygen metabolism, immune response, enhancing local circulation, tissue regeneration and promoting the stimulation of growth factor production.

Accelerating Soft Tissue Repair

Ozone therapy shortens recovery times following surgical interventions by improving oxygen metabolism and localized microcirculation. It prompts the immune system to release vital growth factors, which speeds up tissue regeneration across wounded oral structures. In a clinical trial involving 36 patients, a combination of laser photobiomodulation and ozone therapy drastically enhanced palatal epithelial wound healing while reducing patient morbidity following tissue harvesting. Similarly, randomized controlled trial compared platelet-rich fibrin to topical ozonated oil for palatal wounds after free gingival grafts. The study confirmed that topical ozonated oil achieved a massive, statistically significant improvement in soft tissue re-epithelialization.

Surgical Site Disinfection

In oral surgery, ozone gas or fluid applications help sterilize surgical wounds, limit post-operative infections, and minimize clinical complications. Ozonated glycerin may be applied directly to extraction sockets or surgical wounds to provide localized antimicrobial activity while supporting tissue regeneration.

Pain Management

Pt’s with ozone therapy reported less post-op pain. This is true for some cases where opioids were unable to provide pain relief.

For third molar outcome pain relief, the ozone efficacy for pain reduction is mixed. However, it has been demonstrated that ozonated oil was as effective as conventional antibiotics and analgesics in managing inflammation and pain.

8. Implantology

Surgical Preparation

During implant placement, clinicians can prepare the bony socket traditionally and then bubble gaseous ozone into the site for approximately 40 seconds before inserting the fixture. This step prompts osteointegration, speeds up bone regeneration, and lowers the risk of immediate surgical infection.

Biofilm Decontamination

Ozone's strong anti-biofilm properties make it useful for purging bacteria from exposed implant surfaces. In cases of active peri-implantitis, utilizing ozone provides encouraging clinical outcomes by eradicating localized bacterial colonies and stimulating tissue healing around the failing implant.

Post-Op

Many studies show the use of ozone during surgery had positive effects with less pain and inflammation and improved early healing. In addition, ozone was advantageous for improving clinical parameters of peri-implant mucositis disease-related defects and gene expression in recent systematic reviews.

Peri-Implant Mucositis and Peri-Implantitis

Peri-implant mucositis and peri-implantitis remain significant challenges in implant dentistry. Ozonated glycerin may offer a means of reducing microbial contamination around implants without the risk of promoting antibiotic resistance.

9. Pediatrics

Ozone has several potential applications for pediatric dentistry. In some situations, ozone can be an advantageous alternative for safety and compliance with regards to traditional antiseptics. Chlorhexidine when used as a mouthwash has a strong taste and therefore the compliance for children may be decreased. Ozone may be a more palatable option.

Ozonated water may be an alternative, safer endodontic irrigant for root canal obturation in primary teeth.

Ozonated glycerin may be particularly useful in pediatric patients because of its ease of application and potential ability to reduce cariogenic bacterial populations without invasive treatment. By decreasing acid-producing microorganisms and creating a more favorable environment for remineralization, ozone-based therapies may help arrest or slow the progression of non-cavitated lesions.

Ozone can be helpful for disinfecting deep cavities in pediatric dentistry. It can help avoid irreversible pulp damage when the ozone is applied in combination with demineralizing substances after the infected soft dentin is removed.

10. Oral Medicine and Pathology

Ozone has been used as a safe and reliable alternative or an adjunct treatment for some ulcerative lesions. The anti-inflammatory and antimicrobial properties of ozone have generated interest in the treatment of oral mucosal conditions.

Some of these ulcerative lesions include traumatic ulcers, oral lichen planus, cancer-induced oral mucositis and some lesions from infectious disease origin. There is a lack of standardized protocols for these conditions, but one study found better outcomes using ozonated oil vs water. Despite this, two systematic reviews found that ozone usage resulted in reduced pain, less lesion severity and shorter healing times. It also had no adverse effects. Ozonated glycerin may also be applied to aphthous ulcers, traumatic lesions, denture-related stomatitis, and other inflammatory conditions to promote healing and reduce microbial colonization. Experimental studies suggest that ozone may accelerate epithelial repair, improve local circulation, and decrease inflammatory mediator production, potentially resulting in faster resolution of painful lesions and improved patient comfort.

RAS (Recurrent Aphthous Stomatitis) and HSV (Herpes Simplex Infections) outbreaks had high success rates using ozone. If treated early and frequently with ozone gas, herpes labialis lesions can disappear within 3 days using 3 applications of ozone. Some aphthous ulcers can resolve as soon as 24 hours with ozone treatment using 3, 2 minute ozone applications.

Denture-related sores have reduced pain and faster healing (reduced duration and size) with ozone treatment for 60 seconds.

Ozone can also be helpful in clearing *Candida* infections. It has been a highly effective strategy for clearing severe cases of oral thrush and suppressing candida loads.

11. Head and Neck Oncology

ORN/ONJ Prevention and Management

Ozone has shown beneficial effects for ONJ (osteonecrosis of the jaw) compared to controls for lower pain scores, accelerated healing and lower incidence of post-op complications. It has demonstrated positive effects for both prevention and wound healing after extraction for ORN (osteoradionecrosis) for high risk patients. The three steps included ozone gas application to the relevant section of the gingiva for 40s using a gingival probe followed by alveolus ozonation after extraction. Ozone was also applied after suturing to speed up healing and stimulate circulation.

Ozone has led to complete healing of osteonecrosis of the jaw, including alleviating all associated symptoms.

If ONJ is already present, it can also be useful as a post-surgical treatment.

Cancer-Related Oral Mucositis

Lower pain scores, faster healing times and lower incidence/severity were all promising results from clinical studies for oral mucositis.

12. Esthetics

Two studies have shown 10% ozonized (60 µg/mL) carbamide peroxide (CP) was as effective as CP alone for the whitening of teeth. In addition, it had other benefits compared to CP such as a more stable pH, less enamel surface modification and significantly shorter application time.

13. Oral Microbiome and Preventative Dentistry

Ozonated glycerin may serve as a non-antibiotic adjunct for supporting oral microbial balance. Ozone exerts broad-spectrum antimicrobial activity through oxidative mechanisms rather than traditional antibiotic pathways. Therefore, it may help reduce pathogenic microbial populations without contributing to antibiotic resistance. The ability to apply ozone in a stable, tissue-adherent formulation may make ozonated glycerin particularly useful for maintenance protocols, periodontal support programs, and conservative approaches aimed at preserving oral tissues while reducing microbial burden.

14. Purifying Dental Unit Water Lines

Stagnant water lines inside dental units can accumulate dangerous biofilms containing yeasts, bacteria, and molds, which create aerosol risks for both patients and staff. Ozone has emerged as an ideal purification solution because it leaves no toxic chemical residue. In fact, introducing very low doses of ozone for short durations can clear up to 57% of established biofilms and destroy 65% of active bacteria within model water delivery lines.

15. Clinical Safety, Equipment Comparisons and Contraindications

In general, ozone is highly biocompatible. However, concentrated gas is toxic to the respiratory tract, eyes, and lungs because these tissues possess very few protective neutralizing antioxidants. Inhaling the gas causes throat irritation, heavy coughing, lipid peroxidation that damages deep lung structures, and breathing problems. Therefore, direct inhalation is strictly forbidden, and operator settings require proper ventilation and secure suction devices. Minor side effects from clinical treatments can include headaches, nausea, fatigue, tearing of the eyes (epiphora), rhinitis, vomiting, or a painful vagal nerve reaction during localized infiltration.

Directly injecting ozone gas intravenously is very dangerous because it carries a fatal risk of creating air emboli. Clinicians must identify patient contraindications before administering therapy. Ozone therapy is completely forbidden for individuals experiencing pregnancy, severe anemia or thrombocytopenia, hyperthyroidism, active hemorrhaging from any organ, acute alcohol intoxication, a recent myocardial infarction (heart attack), glucose-6-phosphate dehydrogenase (G6PD) deficiency and known ozone allergies.

In dental applications, equipment engineering is a critical factor in patient safety. It is important to have a system set up that ensures a suction seal with zero leakage to promote a safe clinical environment. To lower the risk of complications, ozone therapy should be performed by professionals with proper ozone training in dosages, application techniques and operating machinery. When used correctly, ozone is considered to be a safe and promising treatment for many dental conditions.

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