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Ozone: An underrated tool in pediatric dentistry

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Abstract
Ozone has long been used successfully in the medical industry. It is not a new substance but it is one of the most recent conventional and therapeutic dental methods. It is used in the form of oil, water and gas. It is economical and gives a better prognosis for the treatment. It is utilized in periodontal treatments, as well as a disinfectant, irrigating substance, and antibacterial agent. Ozone's adaptable bio-oxidative property has recently made it famous. Data on its potential applications in paediatric dentistry have been gathered and are presented in this review article.

Keywords: elastic modulus, flexural strength, provisional restorative materials

Introduction
The Greek word "ozein," which denotes an odorant or fragrant substance, is where the name "ozone" comes from. It is a gas that is found in trace levels in ambient air and has a distinctive, deep scent [1, 2]. It exists organically as a strong-smelling gas in the lower stratosphere, with its primary purpose being to absorb hazardous UV radiation that is part of the sun's light spectrum and therefore safeguard life on Earth [3].
Ozone therapy is a flexible bio-oxidative treatment in which oxygen or ozone is given as a gas or dissolved in water or oil base of water or oil to achieve therapeutic effects. This ‘blue gas’ is used in dentistry because it has antibacterial, irrigating, and disinfecting qualities [4].

History

Year	Highlights
1840	Christian Friedrich, a German chemist, made the initial discovery of ozone. The pioneer of ozone therapy [5].
1857	The initial Ozone generator for medical application has been developed by German physicist Joachim Hensler and physician Hans Wolf [6].
1870	Dr. C. Lender first used Ozone in the medical field for purifying blood in test tubes [6].
1883	Dr. Charles Kenworthy wrote about his Ozone therapy experiences in the Florida Medical Journal. Ozone was utilised to treat wounded soldiers in the trenches during World Wars I and II [6].
1930	Dr. E.A. Fisch, a German dentist who practised in Zurich, Switzerland, frequently used ozone and wrote a lot about it [7].
2001	One textbook on the application of ozone in medicine was written by Dr. Sieg Fried [6].
2004	“Ozone – The Revolution in Dentistry”- Prof. Edward Lyrics [6]

Chemistry
Three oxygen atoms arranged in a cyclical pattern make up the blue gas known as ozone [2]. It has a molecular weight of 47.9 g/mol and is a triatomic molecule containing 3 oxygen atoms [1]. UV radiation and electrical discharges in the atmosphere combine to create ozone (O3) from oxygen (O2). Due to its status as an oxygen allotrope, it is less stable. Three different procedures of producing ozone gas:

- Low quantities of ozone produced by the ultraviolet system are used for air and water cleansing, saunas, and aesthetic purposes.
- It is also produced by a cold plasma system.

- Ozone is produced in large quantities by Corona's discharge mechanism.

Ozone can be administered topically, gaseously, subcutaneously, intravenously, or as ozonated olive or sunflower oil. It serves as irrigation for periodontal infections, herpetic lesions, and stomatitis. Insufflation is employed to treat periodontal disease, decaying teeth, and endodontic issues the treatment of periodontal disease, decaying teeth, and endodontic issues [3, 4].

The ozone generator that is sold commercially is the HealOzone which was created by CurOzone USA Inc. (Canada) for dental application and is presently sold by KaVo Dental (Biberach, Germany). Ozone is a potent oxidant with the ability to operate as a metabolic, antibacterial, and immunological regulator. Numerous microbiological and biochemical research have established the efficacy of ozone in reducing bacterial populations, proving that there is no room for dispute. Additionally, ozone is utilized to sterilize medical equipment and purify drinking water as well as water used in dental tools [8].

Mechanism of action

Ozone has a variety of functions, including bioenergetic, antibacterial, reducing inflammation, analgesic, Immunostimulants, antihypoxic, detoxifying, and biosynthetic (stimulation of the metabolism of carbohydrates, proteins, and lipids) activities [9].

Antimicrobial action

Oxidation of microbial biological components causes ozone to have an antibacterial effect. Healthy human body tissue cells have free radical scavengers like superoxide dismutase, catalase, and hydrolase as well as antioxidant vitamins C and E, beta-carotene, selenium, methionine, and glutathione that obstruct the uncontrolled activity of free radicals, protecting all healthy cells from harm. As a result, it does not harm healthy cells [10].

Only cancer cells and other dangerous cells without this defence system, as well as bacteria, viruses, fungi, and parasites lacking these antioxidants and scavengers, are eliminated [11].

Polydorou *et al*. compared the KavoHealozone device's antibacterial efficacy on S. mutans to the already established performance of two dentin bonding systems. It was discovered that using ozone for 80 seconds is a very promising treatment for getting rid of lingering microorganisms in deep cavities, perhaps improving the clinical outcome of restorations [12, 13].

Analgesic and anti-inflammatory action

Leukotrienes, and prostaglandins, Interleukins which are helpful in lowering inflammation and discomfort, are produced as a result of ozone therapy. Since ozone is negatively charged (basic) and the infection or inflammation is positively charged (acidic), the chemical makeup of the infection or inflammation attracts ozone to the location [14].

Anti-hypoxic action

Ozone triggers a rise in PO2 in tissues and enhances oxygen transport in the blood, which changes cellular metabolism and activates aerobic processes and makes better use of available energy sources. The carious lesion's dangerous bacteria are killed by ozone, and the organic substance inside the carious dentin is also oxidised. Ozone is a potent and trustworthy antibacterial agent that is effective against bacteria, fungi, protozoa, and viruses in both the gaseous and aqueous phases. It is well acknowledged that bacteria and fungi's cell walls and cytoplasmic membranes are destroyed by the oxidising potential of ozone [14].

Different forms of ozone

Ozone is employed in dentistry in a variety of ways, including as a gas, an oil, and an aqueous solution. Dental diseases are treated using either one of these forms alone or in combination [15].

Ozone gas

The different systems for generating ozone gas are:

- Ultraviolet system
- Corona discharge system
- Cold plasma system

Ozone oil

Ozonated oils are naturally occurring derivatives of plant extracts; they are exposed to both pure oxygen and ozone. In particular, mycobacteria, Staphylococci, Streptococci, Enterococci, Pseudomonas, and Escherichia coli are all susceptible to ozonized oil (Oleozone and Bioperoxoil) [13, 16].

Ozone aqueous solution

Uses for aqueous ozone include disinfectant, sterilant, irrigation fluid, and hemostatic [17]. The morphology of teeth frequently makes maintaining dental hygiene challenging. Plaque-forming bacteria that are loosely adhered to tooth surfaces and other surfaces are reduced by using ozonated water [18]. The first Ozone generator was created by Werner von Siemens in Germany in 1857, and C. Lender reported using it to filter blood in 1870. Werner von Siemens also invented the first Ozone generator [19].

Dental Applications

Disinfectant: Ozone's antibacterial qualities make it a superior disinfectant. Studies have shown that ozone therapy is effective in cleaning gypsum casts and serving as a disinfectant in dental treatment facilities. Over an eight-year period, Filippi demonstrated the effectiveness of ozonated water as a disinfectant on the water in dental treatment units [20].

Prosthodontics

Ozone is utilised for denture cleaning as well as faster ulcer healing because it is an active antibacterial agent and has remarkable healing effects [21]. Clinically, gaseous ozone can be helpful for cleaning detachable prosthetics. There is also proof that applying aqueous ozone to the implant surfaces in addition to amino alcohol can effectively clean them [22].

Root canal treatment

Root canal pathogens like Candida albicans, Peptostreptococcus microns, and Pseudomonas aeruginosa have been proven to be destroyed by ozone. As a result, it is utilised in endodontics as an intracanal irrigant [23].

In peri-implantitis

Ozone, a potent antibacterial, destroys every germ that causes peri-implantitis. Ozone is also very effective at healing wounds [9].

Oral surgery

It had been noted that medical ozone exposure promoted more thorough and quick normalisation of non-specific resistance and T-cellular immunity in patients with chronic mandibular osteomyelitis, hastening clinical recovery and lowering the occurrence of sequelae. Ozonated water demonstrated a quicker rate of healing [14].

Dental Applications in Pediatric Dentistry

Decontamination of avulsed tooth

Ozone can be utilised to disinfect the avulsed tooth because it has broad-spectrum antibacterial activity in water and is biocompatible with human oral epithelial cells and gingival fibroblast cells. According to the literature, mechanical cleaning and disinfection are made easier with 2 minutes of ozonated water irrigation. No adverse consequences were observed [24].

Caries prevention

The American Academy of Paediatric Dentistry has said that "the objectives of restorative treatment are to repair or limit damage from caries, protect and preserve tooth structure, re-establish adequate function, restore aesthetics (where applicable), and facilitate good oral hygiene [25]."

Management of pit and fissure caries

Deep pits and cracks are challenging to clean, making it very probable that food will become lodged there and proliferate bacteria. In these situations, using ozone is very effective. It is advised to clean the fissures before to ozone treatment. The ozone can easily enter cavities thanks to this procedure. It is advised to apply a remineralizing product and seal the clean cracks after the ozone treatment. The smear layer is likewise removed by ozone, exposing the dentin that had been covered by the remineralizing chemical. According to Huth *et al*., ozone application significantly reduced non-cavitated early fissure caries in patients at high risk for developing caries over the course of three months [26].

Restorative Dentistry

Ozone gas has a powerful bactericidal impact on microorganisms within the dentinal tubules of deep cavities when used for an extended period, which improves the clinical success of restorations. One of the properties of a gas is to travel to all the nooks and spaces, so all the viruses, fungi, and bacteria get killed [26].

Fig 1: Ozone bathing in restorations

Fig 2: Ozone generator

Procedure [14]:

1. Oxygen molecules (O2) are converted into ozone gas (O3) using an ozone-generating device.
2. 'Ozone gas' or 'ozonated water' is applied to the patient's teeth and gums, where it acts as a powerful oxidant.
3. Ozone's oxygen atoms interact with bacteria that cause periodontal and dental problems by causing cavities in the teeth. By oxidizing dangerous microorganisms, oxygen destroys them and aids in the breakdown of the plaque biofilm.
4. Since we have more antioxidants and scavengers than infections have, it does not harm healthy cells.
5. Restoration is carried out with a favorable prognosis

Bleaching

After applying bleaching paste to the pulp chamber of non-vital teeth, the discoloration of their crowns is treated. Ozone exposure for 3-4 minutes is then used to cure the condition because of its oxidizing properties. In just a few minutes, the ozone treatment whitens the tooth, giving the patient a grin that seems more vibrant and healthier [27].

Pediatric orthodontics

After receiving full orthodontic treatment, it has been reported that teeth bonded with bonding material had some degree of enamel opacity, with diffuse opacity being the most prevalent type [28]. Additionally, white spot lesions that are visible have been observed to appear 4 weeks after orthodontic treatment [29]. Even though the enamel-bracket interface is the region that is most prone to the development of white spot lesions, microleakage can enter beneath the bracket. Enamel prevention is so crucial in orthodontics [26].

Reduction in dental Anxiety in children

The use of ozone therapy in paediatric settings is primarily supported by the fact that applying ozone is a rapid, simple, painless, and successful technique. These elements of the therapy effectively increase patient compliance and tolerance for the therapy as well as the operator's efficiency. The key to a good paediatric treatment, which can be very successfully accompanied by employing ozone therapy, is developing a positive rapport with a kid patient [30].

Dahnhardt *et al*. In youngsters with dental anxiety, open carious lesions were treated with ozone. Anxiety was almost completely reduced (93%). Trauma to or avulsion of the teeth are the most common situations in paediatric practise. In the past, it has been observed that human oral epithelial cells, gingival fibroblast cells, and periodontal cells are highly biocompatible with aqueous ozone. When replanting an avulsed tooth, ozonated water is recommended since it has no

negative effects on periodontal cells [26].

In comparison to conventional drilling and filling, almost 79.8% of the parents were more agreeable to pay more for this therapy. In order to evaluate the impact of one single, 40-second treatment of gaseous ozone on fissure caries which were not cavitated in permanent molars, Huth *et al*. conducted a split-mouth clinical experiment. When compared to the untreated control lesions in these same patients, the teeth treated with ozone demonstrated slower caries progression.[31] Kronusova M found that initial fissure caries lesions can be successfully remineralized with ozone treatment, either alone or in combination with any acceptable remineralizing solution [14].

Decontamination of toothbrush

After conventional brushing, it was discovered that applying ozone helped to eliminate the bacteria from the toothbrush bristles [32].

Dental unit water lines disinfection

Due to the effectiveness of ozone's antibacterial properties and the absence of any substantial adverse effects, it can be used to purify dental unit water lines and reduce cross-infection [33].

Contraindications

Ozone is beneficial to dentistry, but it should not be used by people with certain medical conditions, including pregnancy, Glucose-6-phosphate dehydrogenase deficiency (favism), recent myocardial infarction, hyperthyroidism, severe anaemia, severe myasthenia, haemorrhage, acute alcohol intoxication, and ozone allergy [34].

Ozone Toxicity

Several ill effects, including epistrophe, upper respiratory tract irritation, coughing, rhinitis, headache, sporadic nausea, breathlessness, blood vessel enlargement, vomiting, poor circulation, heart issues, and occasionally stroke, have been linked to the inconsistent use of ozone. The tremendous oxidant capacity of ozone necessitates proper ozone hygiene. It is crucial to properly scavenge the surplus ozone gas and stop it from leaking into the office setting. All materials that encounter the gas must be ozone resistant, such as glass, silicon, and Teflon, due to ozone's tremendous oxidative power. The patient must be put in the supine position and treated with vitamin E and n-acetylcysteine in the event of ozone intoxication [14].

Conclusion

Ozone is one of the upcoming therapies in dentistry. Ozone has a variety of beneficial effects, including as immunostimulant, analgesic, anti-hypnotic, detoxicating, antibacterial, bioenergetic, and biosynthetic effects. It is the perfect therapy option for paediatric children due to its non-invasive, painless, and atraumatic character, which increases patient acceptability and compliance.

Conflict of Interest

Not available

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