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Ozone Therapy – A Dynamic Treatment Modality in Emerging Periodontics and Peri implantitis

Vimal Thomas Oommen[1*], Anjana Appukuttan[1], Thomas George V[1], Nebu George Thomas[1]

Abstract

Oral cavity comprised of a variety of microbial population which colonizes to form the dental biofilm, which serves as an etiological factor for the periodontal diseases. It is one of the most prevalent diseases in the population with clinically manifestations periodontal pocket formation, clinical attachment loss, alveolar bone resorption and end result with loss of tooth. Disruption of the oral biofilm is essential for the prevention and management of periodontal disease progression which can be achieved with different treatment modalities. Early prevention can be achieved with Scaling and root planing. Supragingival and subgingival scaling can be effectively reduce the bacterial load. Other treatment options include curettage for removing the pocket lining, incision and drainage in cases of periodontal abscess, Local drug delivery for systemic effect of drug in subgingival areas, Gingivectomy, frenectomy, crown lengthening, flap surgery. Advanced treatment measures for the management of periodontal diseases were gaining popularity. Ozone therapy emerges as a new approach for the treatment of periodontal disease. Ozone is a natural gas with potent oxidative action discovered in 1930s. It has many positive effects in both medicine and dental field such as antioxidative, anti-inflammatory, immunomodulating, anti-hypoxic, biosynthetic, and antimicrobial agent. Ozone therapy also effectively enhances the wound healing ability and improves the circulation. Varies modes of applications are available like aqueous, gaseous, and oil. This review article comprises with the features of ozone therapy, its property and treatment options in periodontal disease, which gives as an insight in to the world of ozone therapy.

Keywords: Biofilm; Treatment modalities; Subgingival microbial load; Ozone therapy; Antioxidant; Modes of application

Introduction

Periodontitis is a multifactorial inflammatory disease which is flourished due to some bacterial species of dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus [1]. According to the new concept of periodontal pathogenesis periodontitis is mostly initiated by the dysbiotic and synergistic microbiome rather than by select "periopathogens" such as the red Complex was recently studied. This heterotypic and pro inflammatory microbial communities is the main cause of the tissue destructive host response [2].

Ecological plaque hypothesis stated that the disease is not only limited by suppressing the periodontal pathogens alone but also by inhibiting the factors responsible for the transformation of plaque microflora to pathogenic relationship with the host [3].

Affiliation:

Pushpagiri College of Dental Sciences, Pushpagiri Medicity Road, Perumthuruthy, Thiruvalla, Kerala 689107, India

***Corresponding author:**

Vimal Thomas Oommen, Pushpagiri College of Dental Sciences, Pushpagiri Medicity Road, Perumthuruthy, Thiruvalla, Kerala 689107, India

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Due to this well-organized network of microbial plaque, Patients are unable to remove these microbial community by self-care methods they may require a professional treatment approach [4].

The mechanical removal of microbial plaque and calculus by scaling and root planning is one of the mainstays of periodontal treatment [5]. Other treatment modalities including the use of systemic and local antibiotic has got some limitation, to overcome this limitation the use of oral antiseptics like chlorhexidine, povidone iodine, saline, and hydrogen peroxide for sub gingival irrigation has been used [6-8]. Other strategies including the alteration of subgingival environment by the application of oxygenating agents. It is an alternative approach for the suppression of sub gingival bacteria by changing their environment i.e. anaerobic to aerobic (word ozone perio). Now a days ozone therapy has become popular in dentistry [9]. Ozone is quite effective against gram -positive and gram-negative bacteria, viruses and fungi. It is due to its ability to modulate the immune response which makes it the best therapeutic agent [10].

The word ozone comes from the Greek "ozein" meaning odorant. The allotropic form of oxygen that is naturally occurring in earths atmosphere is ozone which is also known as triatomic oxygen and trioxygen [11]. "Ozone (O_3) is a chemical compound consisting of three oxygen atoms (O_3-triatomic oxygen), a higher energetic form than the normal atmospheric oxygen (O_2), which has got s molecular weight of 41.98g/mol. It is a powerful oxidizer" [12]. Ozone has been demonstrated to have unique qualities and may have practical implications in dentistry and medicine. Ozone has various recognized activities, including antibacterial (bactericidal, viricidal, and fungicidal), immunostimulatory, immunological modulatory, anti-inflammatory, biosynthetic (stimulation of glucose, protein, and lipid metabolism), bioenergetic, anti-hypoxic, analgesic, haemostatic, and others. Ozone has therapeutic uses in a variety of dental treatment techniques. When used in conjunction with conventional therapies, ozone therapy has several advantages [13].

In the dental specialty of periodontics, ozone treatment is growing in popularity. It has been shown that watery ozone has high biocompatibility with epithelial cells, cemetoblast & fibroblasts, indicating potential applications for various dental treatments including peri-implantitis, apical periodontitis, and periodontitis. In periodontics, ozone is used as an adjuvant to scaling and root planing (SRP), rather than SRP alone [14].

History

German scientist Christian Frederick was the first to discover in 1840 in Brazil in Switzerland, in 1870 landler was the first to use ozone in medicine, but ozone was not used in medical practice till 1932 but dr. E.A. fish was the first to use ozonated water as a disinfectant. Dr. E Payr in 1871-1946 used ozone locally to treat gangrenous pulpite and the treatment was successful and he extended the use of O_3 to general surgery. But the fate of ozone treatment was due to the lack of ozone resistant material like nylon, Dacron, Teflon until 1950s after that ozone resistant material were manufactured from that time Joachim Hansler a German physicist joined with Hans wolf who is also a physician developed ozone generator and continued to be base of currently used O_3 equipments [15].

Medical Grade ozone and its composition

Medical grade ozone is a pure mixture of pure oxygen and pure ozone which is in the ratio of 0.05% to 5% O_3 and 95% to 99.5% of O_2. Mostly O_3 are unstable so it is usually prepared immediately before its use. This is because after an hour of its preparation only the half part of mixture will remain as O_3 and rest will be changed back to O_2, due to this effect of ozone it cannot be kept for a long period of time. Due to this faster conversion of O_3 to O_2 it can be limited by associating it with a vehicle that have aqueous properties and viscous properties which promotes the conversion rapidly and also slowing its conversion [16].

Ozone generators

Ozone gas can be generated in three different systems which includes [17]:

-Ultra violet system

-Cold plasma system

-Corona discharge system

Ultra violet system: In this system only a very low concentration of ozone is generated which can be used for air purification and aesthetics.

Cold plasma system: This system is mainly used for the purification of air and water.

Corona discharge system: This system of ozone generation mostly commonly employed in the field of medical as well as dental which is due to the production of a very large concentration of ozone and also its ease of handling and controlled rate of its production.

Mechanism of action of ozone therapy

Ozone therapy has got wide range of actions which includes antimicrobial, analgesic, immune stimulating, antihypoxic and detoxicating. These widespread action of ozone makes it suitable for its application in periodontics [18].

Biological actions

Antimicrobial effect: The anti-microbial effect is, its ability to destruct bacteria, fungi, and viruses. The mechanism of action on cell is by destructing its cytoplasmic membrane

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by ozonolysis and also by ozone induced modification of intra cellular contents, by the action of secondary oxidant effect. But the interesting fact of ozone therapy is, it won't damage the human cell due to its anti-oxidative effect and it is highly selective to microbial cell and also it works efficiently against antibiotic resistant strains. Its efficiency can be increased in liquid atmosphere acidic pH apart from antibacterial it is potent against viral infections; its action is mainly because of the creation of peroxide which cannot be tolerated for the infected cell and also dysregulate the viral protein production due to the shift in activity of reverse transcriptase [19].

As mentioned, it is a potent oxidant. It combines with biomolecules that contains cysteine, methionine, histidine, and cysterine all are components of a bacterial cell. Ozone mainly targets and attack on the thiol group of amino acid cysteine. Unsaturated fatty acid reacts with ozone which can harm the lipid sheath of the virus. Both gram- positive and gram-negative bacteria are sensitive but gram positive is more sensitive compared to gram negative bacteria. Ozone treatment is more efficient against Streptococcus species. It also has action on tocopherols and ascorbinians [20].

Immunostimulating effect: Low concentration of ozone has immunostimulating effect and immunodepressive effect with high level of O_3 [20]. Ozone exert influence on cellular and humoral immune system. It is by the proliferation of the immunocompetent cells and also it helps in immunoglobulin synthesis. It also promotes the action of macrophages by increasing the sensitivity of microorganisms to phagocytosis [19]. The activation of ozone aids in the release of cytokine by the immune cells. Cytokines activates various immune cells to resist the diseases [21]. Ozone also helps in the synthesis and production of various cytokines & prostaglandins that helps in controlling inflammation & promotes wound healing [19].

Antihypoxic effect: Anti hypoxic effect is by the increase in level of partial oxygen level in tissues & promotes the O2 transport in blood, which activates the aerobic process due to change in the cellular metabolism. Administration of very low dose of O_3 activates enzymes like catalases,super oxide dismutases, glutathione peroxidases and dehydrogenases which are part of the complex enzymatic systems, protects the organisms from oxygen free radicals. Ozone also prevents the aggregation of erythrocytes and increases oxygen transportation; it is mainly used for treating circulatory disorders [19]. Ozone therapy boosts the metabolism of tissues that are inflamed by promoting their oxygenation and by reducing the inflammatory response [20].

Biosynthetic Effect: The biosynthetic effect is by the regenerative potential of organs & tissues, by increasing its functional activity. Ozone therapy activates the protein synthesis thereby increases the mitochondria & ribosomes count [19].

Analgesic Effect: The analgesic effect is due to the increased stimulation results in the secretion of serotonin and endogenous opioids [22]. To understand that O_2-O_3 has analgesic and anti-inflammatory activities also related to the increased stimulation of the secretion of both serotonin and endogenous opioids. NO can be secreted with the help of ozone therapy which is a vasodilator, it dilates arterioles and venules [19]. It also promotes angiogenesis [20]. Ozone therapy enables the remineralization potential of mineralized tooth by activating the organic substance that are capable of opening dentinal tubules which promotes the diffusion of calcium and phosphorous in carious teeth [23].

Goals of ozone therapy

Setting of therapeutic goals and standard of care are on sound evidence is critical & the ozone therapy goals include [24].

1. Pathogen Elimination.
2. Restoring the O_2 metabolism.
3. Creating a friendly ecologic system.
4. Rapid circulation.
5. Immune system activation.
6. Simulation

Uses of Ozone

Table 1: Uses of ozone.

Periodontics	oral prophylaxis, Gingivitis, Periodontitis, Surgical cuts, Peri implantitis
Oral and Maxillofacial surgery	Coaguloapathy, wound healing, Implantation, Re- plantation
Oral and maxillofacial pathology	Pathogenic infections, abscess, granulomas, fistulaes etc
Prosthodontics and restorative dentistry	Disinfection if cavities & crown
Orthodontics and orthopedics	TMJ dysfunctions
Diagnostics	Vitality test

Routes of ozone Administration

Gaseous Ozone – Administration of gaseous ozone is mainly employed in restorative dentistry and endodontics. It is a noninvasive therapy for dental caries, as it plays the role as disinfectant before restoration and also used for remineralization of hypo mineralized teeth. Topical administration is the preferred method it is achieved by an open system and also by a sealing suction system, it is employed to prevent the inhalation of the gas and to solve other adverse effects [17].

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Ozonated Water– Ozonated water is most commonly used to reduce the oral infections and to destruct various pathogen, because of its ability to destruct the pathogens. Compared to gaseous ozone ozonated water is less effective but the advantage is its ease of application (it is applied for 3min) as gaseous ozone have got a risk of inhalation. Ozonated water is less expensive [17,25-27].

Ozonized Oil- it is most commonly available as sunflower ozonized oil. Ozonized oil is effective against bacterial and fungal infections and it is mostly effective against streptococcus, staphylococcus, enterococcus, pseudomonas and mycobacterium species [17,26,28].

Appliances producing ozone gas

Ozone therapy has been introduced to support many treatments in dentistry, for this various appliance are introduced to produce ozone [29,30].

Heal ozone: Designed by Cur Ozone USA Inc. Now the distribution is done by Kavo Dentals, Germany. This system is sn air-based system with closed circuit. O_3 concentration produced by this system is almost 2100ppm.The important caution to be taken is it requires a perfect airtightness.

Ozonytron: this device works under high voltage and frequency and can be adjusted to an intensity up to five level. It consists of a glass probe formed by a double glass camera and contains a mixture of noble gases which emits electromagnetic energy. When the probe touches the body surface it starts to produce energy. Ozone generated in operation area will be about 10 to 100 µg/mL. since it is not a closed circuit it can be used in gingival pockets.

Prozone: prozone which consist of an attachment that is plastic material (Perio tips and Endo tips) this can be used for different dental procedures. It is recommended for cases of periodontitis.

Ozotop: it is more convenient for use. The generation of ozone is based on the corona discharge system. The main advantage of this system is it can penetrate periodontal pocket.

Customized thermo formed dental appliance: Thermoformed appliance are classified as hard, medium, or soft. They can be used for pocket therapy and can penetrate up to 2-3mm of gingival pocket.

Ozone therapy in periodontics

Periodontitis is a multifactorial inflammatory disease which is related to some bacterial species of dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus [1]. The progression and development of periodontitis depends on risk factors (specific inherited, behavioral or environmental conditions) and risk determinants(genetics, socioeconomic status and gender) [31]. The role of microorganisms & the host immune response and the etiology of periodontitis is well studied and established.

Treatment in periodontitis using ozone came to be a well-known for its antiseptic properties and its disinfectant action. As mentioned above, various forms of ozone are used for treating oral infection including periodontitis because of its antimicrobial properties. Various studies have done to prove the effect of ozone as a good method for treating periodontitis.

Thanomsub et al. 2002 investigated that ozone therapy inhibits the growth of gram- negative and gram-positive bacteria. Bacterial cultures were exposed to ozone of 0.167/ mg/min/L at time intervals of (0, 5, 10, 15, 30, 60, 90, 120,150 min), cell viability were observed in tested bacteria with in 30min after ozone exposure. Ultra structural changes of treated bacteria were observed using scanning electron microscopy. Some of the bacterial cell showed collapsed and shrunken pattern with in 60min and severe rupture and cell lysis after 90min of ozone treatment. Study concluded that ozone therapy causes cell membrane destruction and lysis reaction of bacterial cell which ultimately leads to bacterial inactivation [32].

Ebensberger et al in 2002 studied the effect of ozonated water irrigation on the root surface of a recently extracted, fully erupted third molar in order to analyse the regeneration of PDL cells. The teeth were irrigated for two minutes at random with ozonated water as well as in sterile, isotonic saline solution, which was used as a control. The periodontal cells underwent immunohistochemistry examination. When ozone was used to irrigate teeth, it was found that the proportion of positive cells to total cells, indicating an increase in metabolism, was greater. According to the study's findings, two minutes of ozonated water irrigation cleaned the root surface mechanically and decontaminated it without harming the cells that make up the periodontal ligament [33].

Nagayoshi et al analyzed the effect of ozonated water on dental plaque and oral microorganisms. 4ml of ozonated water for 10 sec were treated on dental plaque samples, the results of this study showed that the use of ozonated water was very much effective in destruction of gram positive as well as gram negative bacteria and also found to be effective against candida albicans in pure culture. The study thus concluded that ozone therapy has a wide range of action against oral micro flora [34].

Hems and Gulabivalain 2005 conducted a study to evaluate the potential of ozone as an anti-bacterial agent. He used enterococcus faecalis as the test species, gaseous as well as aqueous ozone was used. He found that aqueous form of ozone for 240 s, found to be effective against enterococcus faecalis but gaseous ozone was not effective on enterococcus faecalis biofilm [35].

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Ramzy et al in 2005 conducted a study using ozonated water, ozonated water was irrigated in to the periodontal pocket in 22 patients who were diagnosed with aggressive periodontitis. 150ml of ozonated water was irrigated for 5-10min for 4 weeks using a blunt tipped sterile plastic syringe into the periodontal pocket. Reduction in plaque index, gingival index, bacterial count & pocket depth was noted [36].

Huth et al in 2006 conducted a study and found that ozone in aqueous form showed less cytotoxicity than gaseous ozone and other antiseptic gents (chlorhexidine digluconate [CHX]: 2%, 0.2%; sodium hypochlorite 5.25%, 2.25%; hydrogen peroxide- H2 O2 3%) under most conditions. This study concluded that ozone in aqueous form is very much biocompatible for oral use [26].

Kronusova in 2007 used ozone in preventing caries in fissures of first molars of children, in patients after tooth extraction, in patients with post extraction complications, patients with gingivitis, periodontitis, periodontal abscess etc. Ozone was found to be quite effective in treatment of patients who are diagnosed with gingivitis and periodontal abscess and in 10% of cases who showed post extraction complications [19].

Kshitish and Laxman conducted a randomized, double blinded crossover split mouth study in patients who are diagnosed with chronic generalized periodontitis. The study was done for about 18 days which was divided in two intervals, first interval was 0 to 7 days, wash out period of 4 days followed by second interval of 7 days. Each half of mouth was irrigated subgingivally using either ozone or chlorhexidine at different time intervals. The results showed that there was a greater reduction in plaque index, gingival index and bleeding index in patients who are treated with ozone compared to patients who are treated with chlorhexidine. The results also showed that there was greater reduction of Aa in patients who treated with ozone compared to patients who treated using chlorhexidine. Ozone and chlorhexidine were not effective against p. gingivalis and Tannerella forthyria. The study also showed that ozone was also a potent anti-fungal agent [37].

Huth et al in 2011 conducted a study which was to compare the effect of O_3 with that of chlorhexidine against periodontal pathogens, significant correlation was not observed but found that ozone is efficient than 0.2% chlorhexidine [38].

Dodwad et al in 2011 compared the ozone therapy effect with 0.2% chlorhexidine and povidone iodine in patients with periodontitis. Results showed that ozone served as a potent anti-bacterial agent for periodontal disease both in professional as well as home care use [39].

Al Habashneh *et al.* has out research on the biological and clinical impacts of using ozone as an adjuvant in nonsurgical periodontal therapy. A treatment plan consisting of subgingival SRP with ozonated water (test group) / subgingival SRP with irrigation using distilled water (control group), patients was randomly assigned to 41 patients with chronic periodontitis. In all groups, statistically significant improvement was noted [40].

Sae Hayakamo et al. assessed the microbiological and clinical effects of ozone nano bubble water irrigation as a supplement to subgingival debridement in randomized research. Full-mouth mechanical debridement with tap water (WATER) or debridement with ozone nano bubble water were the two therapy groups to which twenty-two patients were randomly allocated. PPD, CAL, and the percentage of BOP (%) were measured using whole mouth clinical assessments at baseline and four- and eight-weeks following therapy. After four weeks, both groups' clinical measures showed considerable improvements. After four and eight weeks, the ozone nano bubble water group saw a considerably higher reduction in PPD and clinical attachment gain than the WATER group [41].

Sujit lodhe et al in 2018 conducted a study on the efficacy of ozone therapy on Porphyromonas gingivalis count in chronic periodontitis an in vivo study. He concluded that single application of ozone lead to a mild reduction in P.gingivalis count but second round greater improvement in reduction of P. gingivalis count [42].

Soorangi et al 2019 assessed the efficiency of ozone as an adjunct to scaling and root planning a clinical and microbiological study, ozonated water sub gingival irrigation is effective in improving oral hygiene, reducing gingival inflammation, decreasing pocket depth and increasing attachment level when used as an adjunct to SRP in patients with chronic periodontitis [43].

Antonella pulga 2019 assessed the association of oxygen ozone therapy with high power photodynamic therapy: a new protocol for the treatment of periodontopathies, he concluded that oxygen ozone therapy together with laser therapy leads to substantial and rapid benefits for periodontitis patients [44].

In 2020, Maria K et al. published a clinical case report and literature analysis on the use of ozone gas to treat endo perio lesions in a patient with advanced periodontitis. Endodontic therapy comprised irrigation, ozone gas treatment for the root canal, rotary endodontic files for instrumentation, and lateral compaction for obturation. At the 6-month follow-up examination, radiographs revealed that the alveolar bone lateral to the root and the periapical lesion had fully healed. Treatment of endo-perio lesions with an interdisciplinary approach yields good clinical results. When treating patients with severe periodontitis and a bad prognosis, ozone therapy is helpful in treating endo-perio lesions with small periodontal pockets [45].

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A randomized clinical trial on the anti-inflammatory impact of ozone treatment was studied by Marco Colombo et colleagues in 2021. Nonsurgical periodontal treatment was employed to treat ten individuals, and half of the oral sites also received the application of an ozone and chlorhexidine gel. Clinical indices were evaluated when patients were seen at baseline, one month later, and three months later. This study showed that, when compared to the use of chlorhexidine, the use of the ozonized gel in addition to the conventional non-surgical treatment did not differ statistically [46].

Biagio rapone in 2022 conducted a study on gaseous ozone therapy a promising anti-septic adjuvant of periodontal treatment. Statistically significant observation was seen at the baseline and at 3 months, scaling and root planning with ozone is good for treating periodontal disease [47]. Studies are summarized in the table 2.

Table 2: Studies of ozone therapy in periodontics.

Studies		Conclusions
Thanomsub et al. [32]	Ozone on Salmonella sp., Escherichia coli, Staphylococcus aureus, and Bacillus subtilis cell proliferation and ultrastructural alterations.	Bacterial cell membrane destruction was seen, which led to intercellular leaking and ultimately cell lysis.
Ebensberger et al.[33]	Impact of ozonated water irrigation on periodontal ligament cell proliferation sticking to root surfaces	Irrigating ozonated water for two minutes result in both a mechanical cleaning and a root surface decontamination, without causing harm to any periodontal cells that are still present on the tooth surface.
Nagayoshi et al. [34]	The impact of ozonated water on oral microorganisms' permeability and survival.	Ozonated water may be helpful in controlling oral infectious germs in dental plaque and seen that it is efficient in eliminating gram-positive and gram-negative oral microorganisms, oral Candida albicans in pure culture, and bacteria in plaque biofilm.
Hems and Gulabivala [35]	Enterococcus faecalis is used as a test species to determine the effect of ozone as an anti-bacterial agent	After 240 seconds of treatment, ozone in solutions showed antibacterial activity against planktonic Enterococcus faecalis.
Ramzy *et al.* [36]	Ozone-treated periodontal pockets in 22 individuals with severe periodontitis	Significant progress was noted in the quadrants treated with scaling, root planing, and ozone treatment
Huth *et al.* [26]		According to a study, under most circumstances, the aqueous ozone, as a possible antiseptic agent.
Kronusova [19]	Ozone in a prepared cavity following tooth extraction, in the event of problems following the extraction, in patients with herpes labialis, purulent periodontitis, persistent gingivitis, dentition issues, etc.	Ozone application following tooth extraction showed beneficial effect reduces the post operative complications.
Kshitish and Laxman [37]	Ozone and chlorhexidine's comparative effects during subgingival irrigation.	Even if chlorhexidine is relatively substantial, a single ozone irrigation can effectively inactivate germs.
Huth, *et al.* [38]	Ozone efficiency against periodontal bacteria with that of the recognized antiseptic CHX.	Aqueous ozone (20 μgml [−1]) and gaseous ozone (≥4g[−3]) were both more effective than 0.2% CHX, although there were no appreciable differences in their efficacy. As a result, high concentrated aqueous and gaseous ozone deserve more research as antiseptics.
Dodwad *et al.* [39]	examined the effects of oral irrigation on individuals with chronic periodontitis using ozonated water, 0.2% chlorhexidine, and 10% povidone iodine.	Applying local ozone can be a powerful, non-surgical, atraumatic antibacterial treatment for treating periodontal disease in both home and professional settings.
Al Habashneh *et al.* [6]	investigation of the biological and clinical impacts of using ozone as an adjuvant in nonsurgical periodontal therapy.	There was a notable improvement in the parameters of gingival recession, clinical attachment loss, BOP, PPD, PI, and GI.
Sae Hayakamo *et al.* [41]	examined the microbiological and clinical outcomes of ozone nano bubble water irrigation as a supplement to subgingival debridement in the treatment of periodontal disease.	After four weeks, both groups' clinical measures showed considerable improvements. After four and eight weeks, the ozone nano bubble water group saw a considerably higher reduction in PPD and clinical attachment gain than the WATER group. In the NBW3 and WATER groups, BOP (%) decreased by 15.69 and 8.98 at 4 weeks and 13.47 and 6.97 at 8 weeks, respectively.
Sujit Iodhe et al. [42]	Porphyromonas gingivalis count in chronic periodontitis: in vivo research evaluating the effectiveness of ozone treatment.	He concluded that ozone therapy can be utilized as an adjuvant to traditional treatment techniques after finding that a single application of the therapy resulted in a little reduction in the P. gingivalis count, but that the second round showed a better improvement in this regard.
Soorangi et al. [43]	Ozone therapy: A clinical and microbiological investigation on its effectiveness as a scaling and root planning adjunct.	When used as an adjuvant to SRP in CP, ozonated water subgingival irrigation improves oral hygiene, reduces gingival inflammation, decreases pocket depth, and increases attachment level.

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Antonella pulga [44]	Relationship between high power photodynamic treatment and oxygen ozone therapy.	When combined with laser therapy, oxygen ozone therapy provides significant and quick advantages for individuals with periodontitis.
Maria k et al in 2020 [45]	Treatment of an endo perio lesions with ozone gas in a patient presented with aggressive periodontitis.	It was seen that ozone therapy was successful treatment option for aggressive periodontitis
Marco Colombo et al [46]	investigation on the anti-inflammatory properties of ozone therapy.	The use ozonized gel shows significant improvement when compared with CHX.
Biagio rapone [47]	Research on Gaseous Ozone Therapy as a Potential Anti-Septic Supplement to Periodontal Therapy	According to a study, using ozone therapy in addition to SRP had better results for treating periodontitis than using SRP alone.

Ozone therapy in peri implantitis

One difficult biological side effect of dental implants is peri-implantitis, for which there are no established guidelines or dependable treatment plans. It is advised to surgically treat peri-implantitis and decontaminate the implant surface in order to remove any microbial biofilm and leave a surface that is safe for human health and promotes re-osseointegration.48Ozone therapy has been proposed as a novel supplementary therapeutic approach for the management of periodontal disease in recent years. Studies of patients with chronic and severe periodontitis have shown significant improvements in PD, PI, GI, and bacterial count in quadrants treated with ozone therapy as an adjuvant to non-surgical periodontal treatment.49Summarized details of studies related to ozone therapy in periimplantitis are given in table 3.

Table 3: Studies of ozone therapy in periimplantitis.

	Objectives	Conclusion
Mckenna et al. [50]	Whether using gaseous ozone—either alone / in combination with hydrogen peroxide—can help patients with peri-implant mucositis experience less bleeding and plaque surrounding their soft tissues.	In SRT of peri-implantitis, adjunctive ozone treatment dramatically lowered the mean PI and GI levels in comparison to saline irrigation alone.
Karapetian et al. [51]	Examination of peri-implantitis management using ozone therapy, surgery, and traditional methods	In the ozone-treated group, there was an effective decrease in bacteria.
De Waal YC et al. [52]	In terms of PD values, was supplementary ozone therapy better than the control treatment	After a 12-month monitoring period, the PD reduction was 2.39 mm in the control group and 3.52 mm in the ozone group. Both groups' CAL values showed a substantial decrease over the trial.
Schwarz et al. [53]	An extended assessment of surgical treatment for peri-implantitis.	There was aslight improvement in the peri implant condition, long term success can be possible only by controlling the factors responsible for peri implantitis.

Ozone toxicity

Inhaling ozone can be harmful to the lungs and other organs. Ozone treatment complications are rare, occurring about 0.0007 times per application. Epiphora, upper respiratory irritation, rhinitis, cough, headache, infrequent nausea, vomiting, shortness of breath, enlargement of blood vessels, poor circulation, heart issues, and occasionally stroke are known adverse effects. Ozone has a strong oxidative power, therefore anything that comes into touch with it- including silicon, glass, and Teflon- needs to be ozone resistant. If the patient is ozone intoxicated, they should be put in a supine posture and given vitamin E and n-acetylcysteine [54].

Conclusion

Since its introduction in the 1840s, ozone therapy has emerged as the most widely used therapeutic approach for the management of periimplantism and periodontitis. Its antibacterial properties and capacity to regulate immune response make it useful in a variety of dental procedures. Numerous research has demonstrated the impact of ozone on oral microbiota. Because ozone is simple, painless, and suitable for both professional and at-home usage, it is used as an adjuvant to traditional periodontal therapies. This is due to its in vitro biocompatibility with oral epithelial cells, gingival fibroblast cells, and periodontal cells. However, ozone therapy's therapeutic use has not yet received enough attention or been used extensively.

References

1. Papapanou PN, Sanz M, Buduneli N, et al. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. Journal of periodontology 89 (2018): S173-182.

Oommen VT, et al., Dent Res Oral Health 2024
DOI:10.26502/droh.0081

2. Hajishengallis G, Lamont RJ. Beyond the red complex and into more complexity: The polymicrobial synergy and dysbiosis (PSD) model of periodontal disease etiology. Molecular oral microbiology 27 (2012): 409-419.

3. Vinutha RS, Lakshmanan R. Ozone and Its Role in Periodontal Therapy- A Review. IOSR-JDMS 13 (2014): 107-110.

4. Katti SS, Chava VK. Effect of ozonised water on chronic periodontitis- A clinical study. Journal of international oral health JIOH 5 (2013): 79.

5. Kotsilkov K, Popova C, Dosseva V. Effectiveness of Target Antimicrobial Therapy of Severe Chronic Periodontitis Part i: Reduction of Gingival Inflamation and Active Periodontal disease Sites. Jimab 16 (2010): 18-20.

6. Hoang T, Jorgensen MG, Keim RG, et al. Povidone-iodine as a periodontal pocket disinfectant. Journal of periodontal research 38 (2003): 311-317.

7. Slots J. Low-cost periodontal therapy. Periodontology 60 (2012): 110-137.

8. Wennström JL, Heijl L, Dahlén G, et al. Periodic subgingival antimicrobial irrigation of periodontal pockets: (I). Clinical observations. Journal of clinical periodontology 14 (1987): 541-550.

9. Taşdemir Z, Alkan BA, Albayrak H. Effects of ozone therapy on the early healing period of deepithelialized gingival grafts: a randomized placebo-controlled clinical trial. Journal of periodontology 87 (2016): 663-6671.

10. Srikanth A, Sathish M, Harsha AV. Application of ozone in the treatment of periodontal disease. Journal of pharmacy & bioallied sciences 5 (2013): S89.

11. Chemical technology an encyclopedic treatment, vol 1, New York: Barnes & Noble, Inc. (1968) pp: 79.

12. Stopka P. Ozon. Progresdent. Prague Medical Report 6 (2003): 8-11.

13. Das S. Application of ozone therapy in dentistry. Rev Ind J Dent Adv 3 (2011): 538-542.

14. Deepthi R, Bilichodmath S. Ozone therapy in periodontics: A meta-analysis. Contemporary Clinical Dentistry 11 (2020): 108.

15. Tekale A, More B, Thakur R, et al. Ozone Therapy-An emerging prospectus in Periodontics. Journal of Interdisciplinary Dental Sciences 6 (2017): 32.

16. Gupta G, Mansi B. Ozone therapy in periodontics. Journal of Medicine and Life 5 (2012): 59.

17. Nogales CG, Ferrari PA, Kantorovich EO, et al. Ozone Therapy in Medicine and Dentistry. J Contemp Dent Pract 4 (2008): 075-084.

18. Bocci V. Biological and clinical effects of ozone. Has ozone therapy a future in medicine? Br J Biomed Sci 56 (1999): 270-279.

19. Seidler V, Linetskiy I, Hubalkova H. Ozone and Its Usage in General Medicine and Dentistry. A Review Article. Prague Medical Report 109 (2008): 5-13.

20. Teresa B, Wolanska E, Cieszko-Buk M, et al. Annales Universitatis Maria Curie; Sklodowska. Lubin-Polonia (2008).

21. Seaverson K, Tschetter D, Kaur T. Health centered cosmetic dentistry. Patient guide to oxygen/ozone therapy (2010).

22. Rania V, Marcianò G, Casarella A, et al. Oxygen–Ozone Therapy in Cervicobrachial Pain: A Real-Life Experience. J. Clin. Med 12 (2023): 248.

23. Lynch E. Leczenie prochnicy z wykorzystaniem system healOzon. eDentico 134 (2004): 3

24. Mollica P, Harris R. Integrating oxygen/ ozone therapy into your practice. Hanover Dental (2019).

25. Azarpazhooh A, Limeback H. The application of ozone in dentistry: A systematic review of literature. J Dentist 36 (2008): 104-116.

26. Huth KC, Jakob FM, Saugel B, et al. Effect of ozone on oral cells compared with established antimicrobials. Eur J Oral Sci 114 (2006): 435-440.

27. Holmes J. Zasto. Antimicrobial effect of novel ozone generating device. J Contemp Dent Pract 4 (2004): 23-34.

28. Sechi LA, Lezcano I, Nunez N, et al. Antibacterial activity of ozonized sunflower oil (Oleozon). J Microbiol 90 (2001): 279-284.

29. Mani A, Shukla P, Patel R, et al. Ozone therapy in Periodontics-A]review. Journal of Medical Science and Clinical Research 2 (2014): 3352-3358.

30. Gulafsha M, Anuroopa P. Miracle of ozone in dentistry: An overview. World Journal of Pharmaceutical Research 8 (2019): 665-677.

31. Iliadis D, Millar BJ. Ozone and its use in periodontal treatment. Open Journal of Stomatology 3 (2013): 197-202.

32. Thanomsub B, Anupunpisit V, Chanphetch S, et al. Effects of ozone treatment on cell growth and ultrastructural changes in bacteria. J Gen ApplMicrobiol 48 (2002): 193-199.

33. Ebensberger U, Pohl Y, Filippi A. PCNA-expression of cementoblasts and fibroblasts on the root surface after extraoral rinsing fordecontamination. Dent Traumatol 18 (2002): 262-266.

Oommen VT, et al., Dent Res Oral Health 2024
DOI:10.26502/droh.0081

34. Nagayoshi M, Fukuizumi T, Kitamura C, et al. Efficacy of ozone on survival and permeability of oral microorganisms. Oral Microbiology & Immunology 19 (2004): 240.

35. Hems RS, Gulabivala K, Ng YL, et al. An in vitro evaluation of the ability of ozone to kill a strain of Enterococcus faecalis. Int Endod J 38 (2005): 22-29.

36. Ramzy MI, Gomaa HE, Mostafa MI. Management of aggressive periodontitis using ozonized water. Egypt Med J NRC 6 (2005): 229-245

37. Kshitish D, Laxman VK. The use of ozonated water and 0.2% chlorhexidine in the treatment of periodontitis patients: A clinical and microbiologic study. Indian J Dent Res 21 (2010): 341-348

38. Huth KC, Quirling M, Lenzke S, et al. Effectiveness of ozone against periodontal pathogenic microorganisms. Eur J Oral Sci 119 (2011): 204-210.

39. Dodwad V, Gupta S, Kumar K, et al. Changing paradigm in pocket therapy-ozone versus conventional irrigation. Int J Public Health Dent 2 (2011): 7-12.

40. Al Habashneh R, Alsalman W, Khader Y. Ozone as an adjunct to conventional nonsurgical therapy in chronic periodontitis: a randomized controlled clinical trial. J Periodontal Res 50 (2015): 37-43.

41. Hayakumo S, Arakawa S, Mano Y, et al. Clinical and microbiological effects of ozone nano-bubble water irrigation as an adjunct to mechanical subgingival debridement in periodontitis patients in a randomized controlled trial. Clin Oral Investig 17 (2013): 379-388.

42. Londhe S, Bagul N, Gupta AA, et al. Efficacy of ozone therapy on Porphyromonas gingivalis count in chronic periodontitis: An in vivo study. Journal of Oral Disease Markers 2 (2018): 30-34.

43. Soorgani N, Agrawal R, Khashu H, et al. Efficacy of ozone therapy as an adjunct to scaling and root planing: A clinical and microbiological study. International Journal of Preventive and Clinical Dental Research 6 (2019): 14-16.

44. Pulga A. Association of oxygen-ozone therapy with high-power photodynamic therapy: A new protocol for the treatment of periodontopathies. Ozone Therapy 4 (2019): 55-63.

45. Deepthi R, Bilichodmath S. Ozone therapy in periodontics: A meta-analysis. Contemporary Clinical Dentistry 11 (2020): 108.

46. Colombo M, Gallo S, Garofoli A, et al. Ozone gel in chronic periodontal disease: A randomized clinical trial on the anti-inflammatory effects of ozone application. Biology 10 (2021): 625.

47. Rapone B, Ferrara E, Santacroce L, et al. The Gaseous Ozone Therapy as a Promising Antiseptic Adjuvant of Periodontal Treatment: A Randomized Controlled Clinical Trial. International Journal of Environmental Research and Public Health 19 (2022): 985.

48. Esposito M, Grusovin MG, Worthington HV. Interventions for replacing missing teeth: Treatment of peri-implantitis. Cochrane Database Syst Rev 10 (2012): CD004970.

49. Al Habashneh R, Alsalman W, Khader Y. Ozone as an adjunct to conventional nonsurgical therapy in chronic periodontitis: a randomized controlled clinical trial. J Periodontal Res 50 (2015): 37-43.

50. McKenna DF, Borzabadi-Farahani A, Lynch E. The effect of subgingival ozone and/or hydrogen peroxide on the development of peri-implant mucositis: a double-blind randomized controlled trial. Int J Oral Maxillofac Implants 28 (2013): 1483-1489.

51. Karapetian VE, Neugebauer J, Clausnitzer CE, et al. Comparison of Different Periimplantitis Treatment Methods (2009): 115.

52. De Waal YC, Raghoebar GM, Huddleston Slater JJ, et al. Implant decontamination during surgical peri-implantitis treatment: a randomized, double-blind, placebo-controlled trial. J Clin Periodontol 40 (2013): 186-195.

53. Schwarz F, John G, Schmucker A, et al. Combined surgical therapy of advanced peri-implantitis evaluating two methods of surface decontamination: a 7-year follow-up observation. J Clin Periodontol 44 (2017): 337-342.

54. Matsumura K, Hyon SH, Nakajima N, et al. Surface modification of polyethylene-co-vinyl alcohol hydroxyapatite immobilization and control of periodontal ligament cells differentiation. Biomaterials 25 (2004): 4817-4824.