Ozone in Dental Therapy

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Abstract: A literature search was performed using MEDLINE (PubMed) and other electronic basis from 1991 to 2014. Search included books and journals based on the systematic and critical reviews, *in vitro* and *in vivo* clinical studies on Ozone therapy in dentistry. Ozone has been shown as powerful oxidizing agent capable of interacting as metabolic, immune modulator as well as an antimicrobial agent. It has been used to stimulate remineralisation of recent caries-affected teeth, as a preventive therapy in caries, root caries, intra-canal irrigants in endodontic treatment, treatment of alveolitis, avascular osteonecrosis of the jaw, herpes virus infection, to inhibits plaque formation, an adjuvant in periodontal surgical and maintenance phase and to disinfect implant surface and treat peri-implantitis and in water line to disinfect water.

Keywords: Oxidant, antimicrobial, immune modulator, caries, osteonecrosis, dental problems.

1. INTRODUCTION

Ozone is an unstable gas and it quickly gives up nascent oxygen molecule to form oxygen gas [1]. Ozone is heavier than air and is thus affected by the gravity, protects living organisms by surrounding the earth at 50,000 to 100,000 feet altitude high [2]. It is one of the most powerful antimicrobial agents available for use in medicine and dentistry [3]. It has been used as a circulatory enhancement and stimulation of oxygen metabolism, disruption of tumor metabolism and effectively kills bacteria, fungi, viruses, and parasites at a dramatically lower concentration than chlorine, with none of the toxic side effects [4].

2. HISTORY

German chemist Christian Friedrich Schönbein of the University of Basel in Switzerland is regarded as the father of ozone therapy [5]. In 1840, he discovered ozone when he passed an electric discharge through water, a strange smell was eminated, which he termed as ozone, derived from a Greek word “ozein” which means odour [2, 6]. The first ozone generator was developed by Werner Von Siemens in Germany as early as 1957 and in 1870 Dr. C. Lender first used ozone in medical field for purifying blood in test tubes [7]. In early 20th century Food and Drug Act, revised its use and effect in the field of medicine [8]. The regular use of ozone in Dentistry was first started by Dr. E.A. Fisch, in 1950, who published numerous papers on its application. Dr Ernst Payr further extended its application for general surgery. Dental-application research began with the approval of Institutional Review Board for Human Research from Capital University of Integrative Medicine in Washington, D.C. was started in 2001 and the first formal lecture on oxygen/ozone therapy was given in 2001 at Capital University [6]. Numerous researchers since that time have worked to elucidate the nature and actions of ozone.

The goals [9] of oxygen/ozone therapy are:

1. Elimination of pathogens.
2. Restoration of proper oxygen metabolism.
3. Immune activation.
4. Increased circulation.
5. Simulation of the humoral antioxidant system.
6. Induction of a friendly ecologic environment.

3. BIOLOGICAL ACTIONS

The actions of ozone on human body are that of analgesic, antimicrobial, immune stimulating, anti-hypoxic, detoxicating, biosynthetic and bioenergetic [7].

3.1. Antimicrobial Effect

The antimicrobial action of ozone is non-specific and selective to microbial cells without damaging the human body cells (major antioxidative ability), increases in acidic pH causing damage to the microbial cell cytoplasmic membrane by ozonolysis of dual bonds and also by ozone-induced modification of intracellular contents because of secondary oxidants effects [1]. Intensive irrigation with ozonated water has proved not only for mechanical cleansing but also to

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decontaminate the root surface, with no negative effect on periodontal cells remaining on the tooth surface [2]. Brauner in 1991 [10] demonstrated that the combination of professional tooth cleaning and daily rinsing of the mouth with ozone water can improve clinical findings in cases of gingivitis and periodontitis [11].

3.2. Immunologic Effect

Ozone influences cellular and humoral immune system. It stimulates proliferation of immune-competent cells and synthesis of immunoglobulins [3, 4]. It also activates the function of macrophages and increases sensitivity of micro-organisms to phagocytosis [7]. Ozone administration at low concentrations reactivates the immune system [12] and produces special messengers called cytokines which in turn activate other immune cells, setting off a cascade of positive change throughout the immune system [5]. The effect of ozone on the host immune response has been demonstrated by Huth *et al,* [13] by choosing nuclear factor-kappa *β* system, a paradigm for inflammation-associated signalling/transcription. Their results showed that that NF-k*β* activity in periodontal ligament tissue from root surfaces of periodontally damaged teeth was inhibited following incubation with ozonized medium, suggesting that it has an anti-inflammatory capacity. Ozone is extremely useful for immune activation in patients with a low immune status [5].

3.3. Anti Hypoxic Effect

Ozone brings about the rise of pO_2 in tissues and improves transportation of oxygen in blood, which results in change of cellular metabolism – activation of aerobic processes (glycolysis, Krebs cycle, -oxidation of fatty acids) and use of energetic resources [7]. It prevents the formation of erythrocytes aggregates and increases their contact surface for oxygen trans-portation, makes it valuable in the revitalizing of organic functions [5].

3.4. Biosynthetic Effect

Ozone causes secretion of vasodilators such as NO, causing dilatation of arterioles and venules [14]. It activates mechanisms of protein synthesis; increases amount of ribosomes and mitochondria in cells and these changes on the cellular level explains the elevation of functional activity and regeneration potential of tissues and organs [7]. Ozone has been included in circulatory enhancement, disruption of tumor metabolism and stimulation of oxygen metabolism [16].

4. MODES OF OZONE ADMINISTRATION

4.1. Gaseous Ozone

Ozone generating equipment converts oxygen to ozone [4]. The *in vitro* study [17] evaluating the cytotoxic effects of gaseous ozone and aqueous ozone on human oral epithelial cells and gingival fibroblast (HGF-1) cells revealed its highest level of biocom-patibility.

4.2. Ozonated Water [10]

Ozonated water can be used for its antimicrobial effect to irrigate and disinfect cavity preparations, root canals, periodontal pockets and during ultrasonic scaling. It is used to control various oral infections and pathogens. It has a half life of 30 mins i.e. it should be used as quickly as possible.

4.3. Ozonised Oil

The interaction of ozone with oil of vegetable source produce a mixture of chemical compounds (ozonides and peroxides) with a great germicide power [6]. Topical application of ozonized oil is used in dermatological diseases of viral, fungal and bacterial origin [18]. It is also used as a safe therapeutic alternative in patients with ANUG.

5. DENTAL OZONE GENERATORS

Due to the instability of the ozone molecule, medical grade ozone must be prepared immediately before use and should be used at once because it has a half life of 40 mins at 20 degree centigrade [2]. In order to control the decomposition of ozone into oxygen it can be associated with a vehicle of more viscous properties, to retard the conversion [9].

5.1. Ozone in Dentistry

Indications 0f Ozone in Dental problems [6]:

- Prophylaxis, prevention and remineralization of caries.
- Desensitization of extremely sensitive tooth.
- Discolored teeth.
- Antiplaque effect.

- Endodontic treatment.
- Sub gingival irrigants.
- Healing wounds.

5.2. Contraindications [6]

- Pregnancy.
- Glucose-6-phosphate-dehydrogenase deficiency (favism).
- Hyperthyroidism.
- Ozone allergy.

5.3. Applications

5.3.1. Dental Caries

The gaseous or aqueous form of ozone eliminates the acidogenic bacteria by decarboxylation of pyruvic acid which is produced by acidogenic bacteria to acetic acid. This acetic acid causes the remineralization of carious lesions and also buffers plaque due to high pKa values [19]. Treatment with ozone gas significantly reduced caries progression and in high caries risk patients it aids in arresting and remineralisation of the carious lesions [20]. Ozone treatment being noninvasive provoked least state of anxiety compared to traditional dentistry [21]. Noncavitated lesions were more likely to reverse than cavitated lesions [22-24]. Initial studies have indicated that an application of ozone is capable of clinically reversing root caries [25].

5.3.2. Hypersensitivity

Clinical trials [26] documented gaseous ozone reduces pain immediately after treatment and desensitization of dentine lasts for longer period of time. Ozone removes the smear layer, opens up the dentinal tubules, broadens their diameter and allows the calcium and fluoride ions to flow into the tubules easily, deeply and effectively to plug the dentinal tubules, thus preventing the fluid exchange through these tubules [27].

5.3.3. Ozone Therapy in Endodontics

Ozone after traditional cleaning, shaping and irrigation reduces effectively the number of microorganisms in the root canal [28, 29]. Ozonated oil irrigated is more quick and efficient in canal sterilization than that of conventional irrigation by sodium hypochlorite and sodium peroxide combination [30-32].

5.3.4. Ozone in Restorative Dentistry

Ozone effect on dental materials have concluded [33, 34] that gaseous ozone applied prior to etching and placement of sealant had no negative impact on sound enamel physical properties, including knoop surface micro hardness or contact angle. The longer exposure to ozone gas had a strong bactericidal effect on microorganisms within the dentinal tubules of deep cavities [35] with no negative impact on dentin and enamel shear bond strength of adhesive restoration [36]. Ozone therapy has shown positive results in bleaching of discolored root canal treated teeth, for lightening the yellowish tinge of tetracycline stained rat incisors [37].

5.5.5. Antibacterial Effect of Ozone

5.5.5.1. Biofilm

Ozonated water is highly effective in killing both gram-positive and gram-negative microorganisms but not successful in completely eliminating these bacteria embedded in the biofilm [38]. The influence of ozone gas with photodynamic therapy (PDT) and known antiseptic agents on a multispecies oral biofilm has been investigated and concluded that the matrix-embedded microbial populations in biofilm are well protected towards antimicrobial agents [39].

5.5.5.2. Periodontal Pocket

Reduction in pocket depth, plaque index, gingival index and bacterial count was recorded when treated by combination of scaling and root planning together with ozone application [40]. Local ozone application to treat periodontal disease non surgically both for home care and professional practice have been used [41]. Ozone is effective against many putative periodontopathogenic microorganisms have the potential to be used as an adjunct to mechanical treatment in periodontitis patients [42, 43].

The addition of ozone to ultrasonic cleaning system containing different experimental solutions has shown antibacterial activity against Staphylococcus aureus [44, 45].

6. OZONE THERAPY IN ORAL AND MAXILLOFACIAL SURGERY

Ozone therapy has beneficial effect in the treatment of refractory osteomyelitis, as adjunct with antibiotics, surgery and hyperbaric oxygen [46-48]. Ozone therapy causes stimulation of cell proliferation and soft tissue

healing and this is used in the management of bone necrosis and extraction sites [49]. The new treatment protocol recommends the use of ozone therapy as therapeutic support in the treatment of bisphosphonate related osteonecrosis of the jaws [50].

7. PERI-IMPLANTITIS

Ozone is a powerful antimicrobial that kills the microorganisms causing peri-implantitis [51]. Ozone shows a positive wound healing effect due to the increase in tissue circulation [16]. Ozone not only effectively sterilizes the surface of both the implant and bone but also initiates the reparative mechanism allowing tissue regeneration around the implant surface [51].

8. EFFECT OF OZONE ON WOUND HEALING

Ozone accelerates the healing of soft tissue conditions like apthous ulcers, herpes labialis, ANUG and other gum infections [18]. Irrigation with ozonated water reduces the post extraction healing time by forming a pseudo-membrane over the socket [2]. Ozone synthesize interleukins, leukotrienes and prostaglandins which are beneficial in reducing inflammation and wound healing [7]. Gasiform ozone or ozonized water shows an increased healing compared to wound healing without ozone therapy [52].

9. DECONTAMINATION OF AVULSED TEETH

Decontamination using aqueous ozone on human oral epithelial cells, gingival fibroblast cells and periodontal cells has high level of biocompatibility [53]. A two-minute irrigation of the avulsed teeth with non-isotonic ozonated water provides mechanical cleansing and decontamination of the root surface with no negative effect on periodontal cells remaining on the tooth surface before replantation [54].

10. OZONE AS DENTURE CLEANERS

Gaseous ozone is found to be more effective than ozonated water in reducing the number of viable Candida albicans on dentures [55]. Ozonated oil [56] has shown to be effective against mycobacterium. Ozone has very less impact on the quality of the alloy in terms of reflectance, surface roughness and weight; hence gaseous ozone can be clinically useful for disinfection of removable prosthesis [57] Denture stomatitis can be controlled by topical application of ozonated oil over tissue and denture surfaces [58].

11. DENTAL UNIT WATERLINE SYSTEM (DUWLS)

Ozone therapy is used for the purification of water, due to its efficiency and lack of side effects. Ozone has achieved a 57% reduction in biofilm and a 65% reduction in viable bacteria inspite of being used in very low doses and with a short time of application [59]. The use of ozone in dental units is effective and recommended to be routinely used [60].

12. TOOTH BRUSH DECONTAMINATION

Ozone is one of the most powerful oxidants and can be used to decontaminate tooth brushes. Ozone application has been found to remove the toothbrushes bristles microbiota following conventional brushing [18].

SAFETY OF OZONE IN DENTAL THERAPY [61]

The main features that support its safety as recommended by the European Union (EU) and US Food and Drug Administration (FDA) are as follows:

- The tight-fitting design of the delivery device made by the cup and tooth contains the ozone treatment at the diseased site.
- The device operates by suction only, the pathway for ozone being under negative pressure. Therefore, ozone will not leak out. In the event of a leak, air can leak in but no ozone can leak out owing to the design of the device.
- If the seal is incomplete, a flow sensor shuts down the ozone generator.
- After the delivery of ozone, automatic suction remains on for an additional 10 second to purge away any remaining ozone.

Safety of ozone application has already been reported in various previous studies for the treatment of gingivitis and periodontitis [10].

Today, after 125 years of usage, ozone is recognized modality in sixteen nations. Ozone is used in almost all aspects of dentistry because of its biocompatibility and effectiveness in removing the microorganisms from dental unit water lines [53], the oral cavity [56], and dentures [59]. Administration of ozone is atraumatic and biologically based treatment. It is toxic when inhaled and on intravenous administration [61]. Ozone has been used in pit and fissure caries [25], primary root caries [63], and as an adjuvant in

periodontal surgical and maintenance phase [64]. Limitation of Ozone is that most of the conclusions were assessed from *in vitro* studies [63, 65] due to paucity of clinical studies. Future studies should investigate the role of ozone on repeated or longer applications for any significant effect.

KEY MESSAGE

With the growing knowledge of ozone therapy, an attempt has been made to incorporate this modern science to practice dentistry.

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