Ozone therapy and restorative dentistry: a literature review

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Abstract

Objective: Over the recent years, restorative dentistry has shifted towards practicing preventive dentistry and adopting more conservative and tooth-preserving procedures. This approach is being further reinforced with the emergence of ozone therapy in the management of tooth decay. Ozone therapy is the treatment of the tooth with a mixture of oxygen and ozone. The aim of this review was to provide a comprehensive literature on ozone therapy and on the different areas of restorative dental specialty where this emerging treatment alternative has been found applicable.
Method: The Medline and Google databases were searched for relevant literature using the following terms "ozone therapy and dentistry", "ozone", "atraumatic tooth restoration", "tooth decay and remineralization". Manual library search and review of bibliographies of published literature were also conducted. Publications that discussed what ozone therapy is all about, the history, mechanism of action, production of ozone, toxicity and clinical applications particularly in Restorative Dentistry were extracted.
Result: Ozone therapy causes remineralization of incipient pit and fissure caries as well as incipient root caries. Its usefulness in open lesions has also being demonstrated. Dental decay may sometimes be managed without the conventional anaesthetic, drill and filling. It is also used in Restorative Dentistry for sterilization of removable dentures and avulsed tooth, tooth bleaching and desensitization. There is conflicting evidence regarding its application in endodontics at the moment.
Conclusion: There is some demonstrable emerging evidence to suggest that ozone therapy is useful in restorative dentistry and it could turn around for good the practice of the discipline in the near future. Its mode of application in dentistry ensures its safety.

Key words: Ozone therapy, caries, remineralization, atraumatic restoration

Introduction

Dental caries is a major oral health condition in developing countries, affecting 60-90% of the school children and the vast majority of adults[1]. In order to remove caries, create the required form of preparation that would enable restorative materials to be placed and adapted and contoured to restore form and function, it is sometimes necessary initially to cut through and then cut away part of the enamel of the tooth to be treated[2,3]. This most times, entails the use of dental injection which is one of the recognized barriers to oral health care[4]. Over recent years, the dental profession is said to have shifted towards practicing preventive dentistry and adopting more conservative and tooth-preserving procedures[2,3]. Such progression has been linked to increased consumer demands with regards to comfort of treatment and advances in dental materials science[2, 5]. It is projected that a shift in caries management, based on rational clinical and scientific principles, will continue over the coming decades[2].
This appears to be the case with the emergence of ozone therapy in the management of tooth decay. Ozone therapy is defined as the treatment of patients with a mixture of oxygen and ozone[6]. It has been used for many years as a method ancillary to basic treatment especially in those cases in which traditional treatment methods do not give satisfactory results[6]. Ozone therapy is said to hold great potential as an atraumatic treatment modality to incorporate into dental practice[7]. Oxygen-ozone therapy which initially started as an empirical approach, has now reached a stage where most of the biological mechanism of action has been clarified[8].

Definition of ozone

Ozone is a chemical compound consisting of three oxygen atoms (O_3 – triatomic oxygen), a higher energetic form than normal atmospheric oxygen (O_2)[7,9]. It is present naturally in the upper layer of atmosphere in abundance. It has got capacity to absorb the harmful ultra-violet rays present in the light spectrum from the sun, thus ozone filters the light spectrum high up in the atmosphere and protects the living creatures from the ultraviolet rays[10].

Ozone protects living organisms by surrounding the earth at altitudes of 50,000 to 100,000 feet[11]. The protective layer of ozone is seen as the blue-coloured sky[7,9].

Mechanism of action of ozone therapy

Ozone in the gaseous and aqueous phase has been shown to be a powerful and reliable antimicrobial agent against bacteria, fungi, protozoa, and viruses [12-14]. It is generally accepted that the oxidant potential of ozone induces the destruction of cell walls and cytoplasmic membranes of bacteria and fungi. During this process, ozone attacks glycoproteins, glycoliplids and other amino acids and inhibits and blocks the enzymatic control system of the cell[14,15].This results in increases in membrane permeability, the key element of cell viability, leading to immediate functional cessation. Then ozone molecule can readily enter the cell and cause the microorganism to die[12, 14, 16, 17]. Also, ozone can attack many biomolecules, such as the cysteine, methionine, and the histidine residues of proteins[14,17]. By ozidizing the biomolecules featured in dental diseases, ozone has a severely disruptive effect on cariogenic bacteria, resulting in elimination of acidogenic bacteria[14, 18].

The strongest naturally occurring acid, produced by acidogenic bacteria during cariogenesis is pyruvic acid. Ozone can decarboxylate this acid to acetic acid[14, 18]. It has been shown that the remineralization of incipient carious lesions can be encouraged when the production of acetic acid, or other high pka acids found in resting plaque, buffers plaque fluid[14, 19]. Ozone does interact with blood components (erythrocytes, leucocytes, platelets, endothelial cells and the vascular system) and positively affect oxygen metabolism, cell energy, the immunomodular property, antioxidant defense system, and microcirculation[14, 20-22]. Following activation by ozone, the immune system produces cytokine, interferons and interleukins. These substances regulate inflammation states and the activity and maturation of immune system cells[23].

Production of ozone

Ozone is produced naturally from electrical discharges following thunderstorms. It is created when an oxygen molecule receives an electrical discharge breaking it into two oxygen atoms. The individual atoms combine with another oxygen molecule to form an O3 molecule[7, 9]. It is also produced from ultraviolet rays emitted from the sun which plays the role of electrical discharge over oxygen present in the atmosphere, thus, creating the ozone layer which absorbs most of the ultraviolet radiation emitted by the sun[7, 9]. Ozone also forms near ground level as a result of the reaction of ultraviolet light with hydrocarbons, nitrogen oxide and sulphur compounds to produce photochemical smog. Ozone is not the cause of the smog, but a by-product[11]. In the clinical setting, an oxygen/ozone generator stimulates lightening via an electrical discharge field[11]. In a medical/dental ozone generator, the medical grade O2 is converted to O3 in special tubes via a corona discharge reaction (similar to lightening)[11]. This type of generator is able to control the concentration of ozone critical to delivering the correct dose in micrograms/milliliters (mcg/ml)[11]. Concentration is determined by exposure and contact time of the medical grade oxygen to the 5 to 13 millivolts [Bocci] sealed-corona discharge tubes[11]. Other systems for generating ozone gas include: ultraviolet and cold plasma systems[7, 9]. Ultraviolet system produces low concentration of ozone. It is used in aesthetics, saunas, and for air purification. Cold plasma system on the other hand is used in air and water purification[7, 9].

Medical grade ozone is made from pure medical oxygen because oxygen concentration in the atmosphere is variable[7]. Atmospheric Air is made up of nitrogen (71%) oxygen (28%) and other gases (1%) including ozone which is altered by processes related to altitudes, temperature, and air pollution[7]. Because of ozone's physical properties in the dental model, the ratio of oxygen to ozone is extremely low[11]. The typical average concentration of ozone used in treatments is 25 micrograms of ozone per milliliter of oxygen/ozone gas mixture that translates into 0.25 parts of ozone to 99.75 parts of oxygen. Evidence-based research has shown that at this concentration, ozone effectively kills bacteria, fungi, viruses, and parasites[11].

Due to the instability of the O3 molecule, medical grade ozone must be prepared immediately before use. Within less than an hour after preparation only half of the mixture is still O3 while the other half is transformed into oxygen. As a result it is impossible to store ozone over long periods of time. In order to control the decomposition of O3 into oxygen it can be associated with a vehicle with aqueous properties to promote the conversion more quickly or with a vehicle with more viscous properties to retard the conversion[7].

History of ozone therapy

Christian Friedrich Schönbein, a German chemist is considered to be the father of ozone therapy (1840)[7, 10]. When he passed an electrical discharge through water, a strange smell was produced, which he called ozone, from the Greek word ozein (odour)[7,10]. The first medical application was in 1870 when Dr. C. Lender purified blood in test tubes [11]. Oxygen/ozone therapy was in use in the United States in 1885 when Dr. Charles Kenworthy, a Fluorida physician published his experiences with ozone in the Florida Medical Association Journal [11]. As of 1929, more than 114 diseases were listed for treatment with oxygen/ozone therap [11]. Dr. Edward Fisch (1899-1966) was the first dentist to use ozonated water in his practice in 1930. He introduced it to the German surgeon Dr. Erwin Payr (1871-1946) who used it from that time onward in surgery and reported his results at the 59th Congress of the German surgical society in Berlin (1935)[14, 24]. At the time, ozone therapy was difficult and limited due to the lack of ozone-resistant materials such as Nylon, Dacron, and Teflon, until 1950 when ozone-resistant materials were manufactured[7, 10]. At the time Joachim Hänsler, a German physicist and physician, joined another German physician, Hans Wolff, to develop the first ozone generator for medical use. Their equipment continues to be the basis for modern equipment[7].

Modes of applications of ozone

Presently, there are nine methods of ozone therapy application in medical practice namely: direct intra-arterial and intravenous applications, rectal insufflations, intramuscular injection, major and minor auto

haemotherapy, ozonated water, ozonated oil, intra-articular injection, ozone bagging and inhalation of ozone [25]. However, there are three basic forms of application to oral tissue: ozonated water, ozonated oil and oxygen/ozone gas. Ozonated water and olive oil have the capacity to entrap and then release oxygen/ozone, an ideal delivery system [11].

Ozone therapy in prosthodontics

It had been found that application of ozone therapy is useful in reducing the number of microorganism load on denture bases. Direct exposure to gaseous ozone was reported to be more effective in this regard [12-26-28]. Ozone therapy may also be applied to abutment teeth to disinfect them before crown/fixed denture cementation. In this way, the risk of secondary caries developing under the restoration is minimized[23].

Ozone therapy and dental caries

Ozone can be used to kill bacteria present in carious lesion, painlessly and even without anaesthetic [10,29]. In cases of incipient caries, ozone can kill bacteria in the demineralized part and this demineralized tooth structure then, can be remineralized using a special remineralization kit containing calcium, Fluorine, Phosphorous and Sodium, all in ionic forms [10,29]. Studies have revealed that application of ozone significantly remineralized primary pit or fissure caries [30-32]. One clinical study that evaluated the efficacy of ozone gas in the reversal of caries in open single- surface lesions also showed promising results in terms of hardness of the occlusal floor over time [33]. Remineralization of primary root caries treated with ozone had also been reported [34, 35]. Celiberti et al. [15] assessed the influence of ozone on enamel prior to etching and sealing and concluded that ozone can be applied over intact and prepared enamel during restoration process.

Ozone therapy and tooth bleaching

It is a useful supportive treatment in tooth bleaching. Ozone treatment bleaches discoloured root canal treated tooth within minutes and gives the patient a happy and healthier-looking smile when used in combination with the traditional clinic based treatment protocol [10,36].

Ozone therapy and endodontics

Ozone oils (ozonated sunflower oil or olive oil or groundnut oil) can be used to make the root canal systems sterile and to clear the canals of necrotic debris by virtue of ozone's bactericidal and effervescent properties [10]. However, there is conflicting evidence at the moment regarding the application of ozone in endodontics [14]. Nagayoshi et al.[37] reported that ozonated water had nearly the same antimicrobial activity as 2.5% NaOCl during irrigation while the results of a later study showed that NaOCl was superior to ozonated in killing E. faecalis in broth culture and in biofilms [38]. It has also been reported that ozone oil irrigation is quicker and more efficient in canal sterilization than the conventional irrigation by the sodium hypochlorite and sodium peroxide combination[10].

Ozone therapy and desensitization

It has also been documented that ozone therapy can effectively terminate sensitivity arising from exposed root necks within seconds and also results are said to last longer than those achieved by conventional methods [10] Smear layer present over the exposed root surfaces prevents the penetration of Ionic Calcium and Fluorine deep into the dentinal tubules. Ozone removes the smear layer, opens up the dentinal tubules, broadens their diameter and then Calcium and Fluoride ions flow into the tubules easily, deeply and effectively to plug the dentinal tubules [10].

Treatment of avulsed teeth

A high level of biocompatibility of aqueous ozone in human oral epithelial cells, gingival fibroblast cells, and periodontal cells has been found. This is said to be important for decontamination of avulsed teeth before replantation [39,40].

Sterilization of instruments and equipment

Ozone therapy is used for equipment sterilization [14]. Professor Edward Lynch from Queen's university, Belfast, Northern Ireland, who paved the way for the use of ozone dental therapy reported that the best infection control is to place dental instruments in an ultrasonic bath filled with freshly made ozonated water[36].

Application of ozone in medicine and other areas of dentistry

Following an extensive review of the application of ozone in medicine, it has been stated that there is insufficient evidence at the moment to recommend its use as a form of alternative treatment in patients with haematological disorders, autoimmune diseases, ischaemia, eye conditions, ENT, obstetrics and gynaecology, orthopedic conditions, cancer and skin disorders contrary to reported success in these fields. Current data on the usage of ozone therapy as therapeutic options for various health conditions is said to lack sufficient safety and therapeutic advantage over conventional therapeutic modalities [25]. There are few literature on the utilization of ozone in other areas of dentistry. However, its usefulness in plaque control, oral wound healing and treatment of oral soft tissue lesions like aphthous ulcer had been reported [7,10,14].

Ozone Toxicity

Ozone inhalation can be toxic to the pulmonary system and other organs. Known side-effects are epiphora and upper respiratory irritation, rhinitis, cough, headache, occasional nauseas and vomiting. Complications caused by ozone therapy are infrequent at 0.0007 per application. In the event of ozone intoxication, the patient must be placed in the supine position, inhale humid oxygen, and take ascorbic acid, vitamin E and nacetycysteine. Because of ozone's highly oxidative power, all materials that come in contact with the gas must be ozone resistant, such as glass, silicon and Teflon [7].The mode of application in dentistry ensures its safety[7].

Ozone Therapy Contraindications

The following are contraindications for use of ozone therapy [7,9].

- Pregnancy
- Glucose-6-phosphate-dehydrogenase deficiency (favism)
- Hyperthyroidism
- Severe anaemia
- Severe myasthenia

· Active haemorrhage

Cost implications of ozone therapy in dentistry

Ozone therapy is expensive. However, most people may accept the extra financial cost if long term benefits to their health can be seen [41]. As a long time preventive measure in combating tooth decay, it is argued that this treatment is not prohibitively expensive and it saves the time of both the dentist and patient [36].

Conclusion

There is some demonstrable evidence to suggest that ozone therapy is useful in some areas of dental surgery and it could be the arrowhead of restorative dental treatment in the foreseeable future. We are of the view that the current controversies about the usefulness of ozone therapy in restorative dentistry will be settled with time.

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