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Improved tooth bleaching combining ozone and hydrogen peroxide—A blinded study

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ABSTRACT

Objectives: To evaluate the efficacy of tooth bleaching using ozone after hydrogen peroxide (H_2O_2) in comparison to the use of H_2O_2 alone.
Methods: 70 extracted teeth were randomly distributed into two groups. Teeth surfaces in group 1 ($n = 35$) were treated using 38% H_2O_2 and then were exposed to ozone for 60 s and this ozonated peroxide mixture was left on the teeth for 20 min. Meanwhile, teeth in group 2 ($n = 35$) were treated with H_2O_2 38% for 20 min. The L^* a^* b^* and Vita Classic shade values of teeth were evaluated in both groups at base line, after application of H_2O_2 and ozone in group 1, and after application of H_2O_2 and then again after another application of ozone in group 2. The statistically significant changes were set at $P \leq 0.05$.
Results: Baseline L^* a^* b^* and Vita shade values were comparable between groups ($P > 0.05$). Teeth obtained lighter shades following bleaching with both H_2O_2 and ozone or with H_2O_2 alone ($P \leq 0.05$). Further bleaching with ozone for teeth already bleached with H_2O_2 alone showed further improvement of the shades of teeth ($P < 0.001$). Teeth treated with H_2O_2 and ozone had more shade improvements than those only treated with H_2O_2 ($P < 0.001$). Also, L^* values were increased while b^* values were decreased (teeth obtained lighter shades) following bleaching in both groups ($P \leq 0.05$). More changes were obtained when both ozone and H_2O_2 were used ($P \leq 0.05$).
Conclusions: Bleaching with 38% H_2O_2 and ozone resulted in teeth with lighter shades than bleaching with 38% H_2O_2 alone.

1. Introduction

Ozone (O_3) is a triatomic molecule, consisting of three oxygen atoms. Ozone is the third most potent oxidant after fluorine and persulfate [1,2]. Also, it has analgesic properties, has a very potent antimicrobial activity (against bacteria, viruses, yeasts, and protozoa), and has the capacity to stimulate blood circulation and the immune response [1,2]. Such features justify the current interest in its application in medicine and dentistry; and therefore, ozone has been indicated for the treatment of more than 250 different pathologies [1–5].

Ozone therapy is used for many aspects in dentistry including biofilm purging, periodontal pocket disinfection, prevention and management of dental caries, treatment of exposed pulps, root canal treatment, tooth extraction, tooth sensitivity, TMJ treatment, exposed roots, pain control, infection control, acceleration of healing, tissue regeneration, control of halitosis, tooth surface remineralization, and bleaching [1–17].

Different ozone generating machines are used in dentistry including the healOzone and Ozicure machines [7–15].

Previous studies on ozone's role in bleaching are scarce and reported conflicting results [18–21]. Manton et al. [18] found that 8% carbamide peroxide bleaching efficiency was not significantly improved by using ozone. However, Abd Elhamid and Mosallam [20] found that an ozonated gel had better bleaching effect and was associated with less surface roughness of bleached disc-shaped stained resin composite specimens when compared to 30% carbamide peroxide.

Also, some researchers demonstrated that ozone could lighten tetracycline stained incisor teeth in rats [19]. Meanwhile, other researchers demonstrated that ozone could bleach teeth similar to

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Opalescence Quick which contains 45% carbamide peroxide [21]. Previous studies in this regard suffer some pitfalls including the use of unsafe machines to generate ozone [8,21], which followed experimental settings that cannot be applied for clinical settings [21], used subjective visual shade guides to record shade changes [19,21], used very small sample sizes [18,20], used very low concentrations of peroxide [18], primarily assessed extrinsic artificial staining from tea [18] or recorded hue component of the shade only [19].

Numerous studies are present in the textile and pollution literature showing the synergistic benefits of using ozone with peroxide for bleaching and degradation of pollutants and industrial waste products and this is often called advanced oxidative processes [22–26].

This incited the conduction of this study to shed more light on the role of ozone in dental bleaching and to compare its efficacy with conventional bleaching agents.

The aim of this study was to evaluate the efficacy of bleaching using both 38% H_2O_2 and 60 s of ozone applied to teeth for 20 min in comparison to the sole use of 38% H_2O_2 for 20 min.

The null hypothesis for this study was that combining application of both 38% H_2O_2 and 60 s of ozone applied to teeth for 20 min has similar bleaching effects in comparison to the sole use of 38% H_2O_2 also applied for 20 min.

2. Materials and methods

Seventy freshly extracted human teeth including incisors, canines and premolars were used in this study. The study was approved by the Deanship of Research, University of Jordan, Amman, Jordan.

Each tooth was cleaned using normal saline and gauze; and then stored in a 5% thymol solution at room temperature to prevent dehydration of teeth [27]. Thymol solution has an antimicrobial action and was used to store the specimens during the period of tooth collection for this study [27]. A condensation silicone mold was fabricated for each tooth to make it easier to handle the teeth during the study.

The teeth were randomly allocated into two groups after giving each tooth mold a specific number then the teeth were distributed randomly to either group 1 or 2. To detect changes in the shade of each tooth surface, the shade of teeth was evaluated for both groups at base line. The shade was recorded using the Colorimeter Konica-Minolta CR-400 (Minolta Inc, Osaka, Japan). Colorimeters measure the intensity of reflected visible light for red, green, blue and yellow wave lengths (i.e. the coordinates of color space in CIELAB color system) [28,29]. The used colorimeter gives the reading for L^* a^* b^* values and Vita Classic shades. L^* a^* b^* values refer to the dimensions of color space and spatial presentation of the CIELAB color system through the use of L^* a^* b^* coordinates; where L^* determines lightness, a^* determines redness ($+a^*$) or greenness ($-a^*$), and b^* determines yellowness ($+b^*$) or blueness ($-b^*$) [30]. L^* value ranges between zero and 100, a^* value ranges between −90 and 70, and b^* value ranges between −80 and 100.

The colorimeter was used in a custom made booth to standardize the ambient environment during measuring L^* a^* b^* values of the sixteen Vita Classic shades. The colorimeter was fixed in the booth perpendicular to the measured teeth surfaces at a fixed distance of 7 cm away from the measured tooth surface. A cabinet (100 cm × 90 cm × 70 cm) that had a D65 light with 200–300 foot candle intensity was used as the measuring booth following Ozcelik et al. [31] . The lighting unit of the measuring booth had three lamps mounted at different angles around the axis of the mounting unit to avoid creation of shadow and to obtain well distributed illumination at the measuring area. Moreover, lamps were turned on for 30 min before color measuring to produce stable and constant illumination following the recommendations of Gozalo-Diaz et al. [32]. The colorimeter was calibrated before each use by measuring a reference Vita Classic shade (B3) each time before tooth shade measurement under the same conditions.

Then, the facial surfaces of teeth in group 1 ($n = 35$) were treated using 38% hydrogen peroxide professional whitening gel (BMS white 38%, BMS Dental, Italy) with ozone then immediately applied for 60 s into the peroxide on each tooth and this ozonated peroxide mixture was left on the teeth for 20 min. Next the teeth were gently rinsed with water for 5 s and gently air dried with a three in one syringe for 2 s. After that, the shade of teeth was recorded as above. The H_2O_2 gel was applied on teeth surfaces using mixing tips attached on a dual syringe that contains the whitening gel and provided by the manufacturer. The ozone was generated by the healozone® X4 machine (healOzone® X4, Curozone, Germany). The delivered ozone concentration was 2350 ppm at a flow rate of 615 cc per min [14]. The ozone was applied to teeth through special disposable silicone cups provided by the manufacturer. The used silicone cups ensured a complete seal and prevented ozone gas escape as the machine is designed to work only when the cup ensures a perfect seal, and thus this ensures the safety of the healOzone machine for human use [8]. All shade measurements were recorded in the region relating to what would have been the area of the tooth corresponding to where the center of the cup was located.

Meanwhile, the facial surfaces of teeth in group 2 ($n = 35$) were treated using 38% H_2O_2 with air (instead of ozone) then immediately applied for 60 s into the peroxide and this air-peroxide mixture was left on the teeth for 20 min in the way as described above. A specially designed healOzone was used which had a switch at the back of the device which was switched to deliver only air and no ozone. The shade of the teeth was then recorded by an assessor who was not aware of the delivery of ozone or just air. Then, the teeth in group 2 were further exposed to ozone treatment for 60 s and the shade was recorded again as above.

Intraexaminer reliability was established with 10 duplicate shade readings on 10 teeth by the same investigator. Kappa was 0.92, indicating significant agreement as the measuring environment and criteria were standardized, clear and simple. Interexaminer reliability was also assessed by having another investigator record the same 10 shade readings on each of the 10 teeth; Kappa was found to be 0.90, indicating high interexaminer reliability. Two

Table 1
Distribution of L^* a^* b^* shade values among study groups before and after bleaching.

Group	L^* value (SD)		a^* value (SD)		b^* value (SD)	
	Baseline	After bleaching	Baseline	After bleaching	Baseline	After bleaching
Group 1 (bleaching with H_2O_2 + ozone)	81.64(3.43)	85.07(2.90)	−1.75(1.99)	−2.29(1.53)	17.32(4.25)	12.97(3.60)
Group 2 (bleaching with H_2O_2 + air)	81.79(3.00)	83.76(3.19)	−1.98(1.96)	−2.63(1.78)	17.45(5.61)	15.56(3.59)
Group 2 (bleaching with ozone for teeth already bleached with H_2O_2 + air)	83.76(3.19)	84.91(2.83)	−2.63(1.78)	−2.74(1.77)	15.56(3.59)	12.82(3.15)