Evaluation of the Impact of Ozonated Water on Water Sorption and Solubility of Heat Cure Acrylic Resin: An In Vitro Study

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Abstract

Introduction: This study aimed to evaluate the impact of ozonated water on water sorption and solubility of heat-cure acrylic resin. **Methods:** Thirty-three samples of heat-cured acrylic resin were manufactured and divided into three groups: control, immersion for 10 and 20 minutes in ozonated water. Water sorption and water solubility tests were carried out in line with ADA Standard No. 12 for denture-base acrylic resin. Data were analyzed using one-way ANOVA at a significance level of 5%. **Results:** There was a nonsignificant difference between the control and experimental groups regarding water sorption ($P = 0.273$) and was significant for water solubility ($P < 0.001$). Tukey's post-hoc test showed significant differences between control and intervention (OZ-10 and OZ-20) groups regarding water solubility ($P < 0.001$) and nonsignificant differences between OZ-10 and OZ-20 groups ($P = 0.811$). **Conclusion:** Immersion for 10 and 20 minutes in ozonated water can increase water solubility.

Keywords: Heat-cure acrylic resin, denture cleansers, ozonated water, water sorption, water solubility, Fourier transform infrared spectroscopy (FTIR) test

Introduction

Heat-cured acrylic resins are popular in prosthetic dentistry due to their acceptable appearance, ease of clinical usage, optical characteristics, and biocompatibility.[1] However, heat-cured acrylic resin is not considered an ideal denture base material because of inadequate impact strength, bending strength, water sorption, solubility, residual monomer release, and polymerization shrinkage.[2] Water sorption and solubility induced dimensional instability, halitosis, and discoloration of denture base resin, which can affect patient satisfaction. Therefore, using materials with the lowest possible water sorption and solubility rates is desirable since a higher rate of water sorption and solubility is prone to impair material qualities and, thus, shorten the average life span of dentures.[3,4]

Denture cleansers should be used daily to avoid bacteria colonization and promote optimum oral health. Disinfection of dentures has been indicated as the most critical step in maintaining proper denture hygiene. The disinfection process should be efficient while having no negative effects on the physical qualities of the denture base materials.[5-7] Ozone (O_3) is a natural gas composed of three atoms of oxygen. It can be found as a gas in the stratosphere in amounts ranging from 1 to 10 ppm, or it can be produced artificially using ozone generators.[8] In the dental field, ozonated water generated by a home ozone generator provides an effective and low-cost alternative for cleaning the acrylic resin used in denture bases without compromising their properties.[9] This research was done to evaluate the impact of ozonated water on water sorption and solubility of heat-cure acrylic resin.

Material and Methods

The local ethical committee of the College of Dentistry, University of Baghdad, approved the study protocol

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(Approval number: 668222). Thirty-disc samples with a 50 mm diameter and 50 mm thickness for the water sorption and solubility tests and three bar samples of 30 × 15 × 2.5 mm in length, width, and thickness for the FTIR test were prepared from heat-cured acrylic (Ivoclar Vivadent AG, Liechtenstein, German). According to ADA specification No. 12, 1999, the sample size was established. The heat-cured acrylic was mixed in accordance with the manufacturer's instructions and placed into the stone mold. Depending on Ivoclar Vivadent AG's routine polymerization process, the flask was placed in water baths (Broden, Malmoe, Sweden) for 7 h at 70 °C. The water was heated once more to 100 °C, and the flask was kept at that temperature for 45 min. After the curing cycle is completed, allow the flask to cool to room temperature, then separate the flask halves.[10] All specimens after polymerization were finished using silicon carbide grinding papers. The sample surfaces were polished with rouge in a dental lathe system operating at 1500 rpm and utilizing continuous water cooling until a shiny surface was obtained. Samples are divided into three groups: (1) Group (OZ-10): samples soaked in ozonated water for 10 min at a concentration of 2 mg/L. (2) Group (OZ-20): samples soaked in ozonated water for 20 min at a concentration of 2 mg/L. (3) Control group: samples soaked in distal water (control group). A home air ozone generator (Multifunctional Ozonizer and Fruit and Vegetable Detoxification Washer, Qingdao, China) was used to prepare the ozonized water. The output tube was inserted into a glass beaker containing 1000 mL of deionized water. After that, the ozone was bubbled through the water for 30 min. The concentration of dissolved ozone in the water was measured using a CLEANS30 portable dissolved ozone meter (CS6930 dissolved ozone electrode, Changsha, China).

According to Salem and Al-Khafaji, [11] for the water sorption test, all disc samples were maintained for 24 h at 37 ± 2 °C in a desiccator (Rd. Electronics, Busan, Korea) containing well-dried silica gel to dehydrate the specimen. The discs were then transferred to a similar desiccator for 1 h at room temperature. After that, the discs were weighed with an accuracy of 0.02 mg. The dehydration cycle was repeated until each disk's weight loss in any 24-h period did not exceed 0.5 mg (M1). Samples were then immersed in distal water and ozonated water; each disk was taken out of the water using forceps, dried with a clean, dry towel, allowed to air dry for 15 s, and then weighed (M2). The following formula was used to compute the sorption for each disc: sorption (mg/cm^2) = (M2–M1)/surface area. After each sorption cycle, the amount of soluble material lost was calculated by placing the specimens again in the desiccator and weighing them at regular intervals until a constant weight (M3) was attained.[11] The formula was used to determine the solubility of each disc: solubility (mg/cm^2) = (M1–M3)/surface area.

Fourier transform infrared spectroscopy (FTIR) test was used to get a better understanding of the chemical surface alterations that happened on heat-cured acrylic samples after immersion in ozonated water. One sample was used in each study group. After the immersion in a denture cleanser, samples were dried in a dry–heat oven for 12 h at 70 °C to eliminate the H_2 molecules from the structure. The dried samples were then cut into small pieces to get a clear FTIR spectrum.[12] An FTIR spectrometer (Sgimadzu, Tokyo, Japan) was used to record the sample's FTIR spectra after they were set up on the diamond set.

All data were collected, tabulated, and statistically analyzed utilizing R 3.6.3 software (R Foundation for Statistical Computing, Vienna, Austria). One-way ANOVA was used for comparisons between control and experimental groups. The $P < 0.05$ value was considered statistically significant.

Results

According to the ANOVA test, there was a nonsignificant difference between the control and experimental groups regarding water sorption ($P = 0.273$) and was significant for water solubility ($P < 0.001$). Tukey's post-hoc test showed significant differences between control and intervention (OZ-10 and OZ-20) groups regarding water solubility ($P < 0.001$) and nonsignificant differences

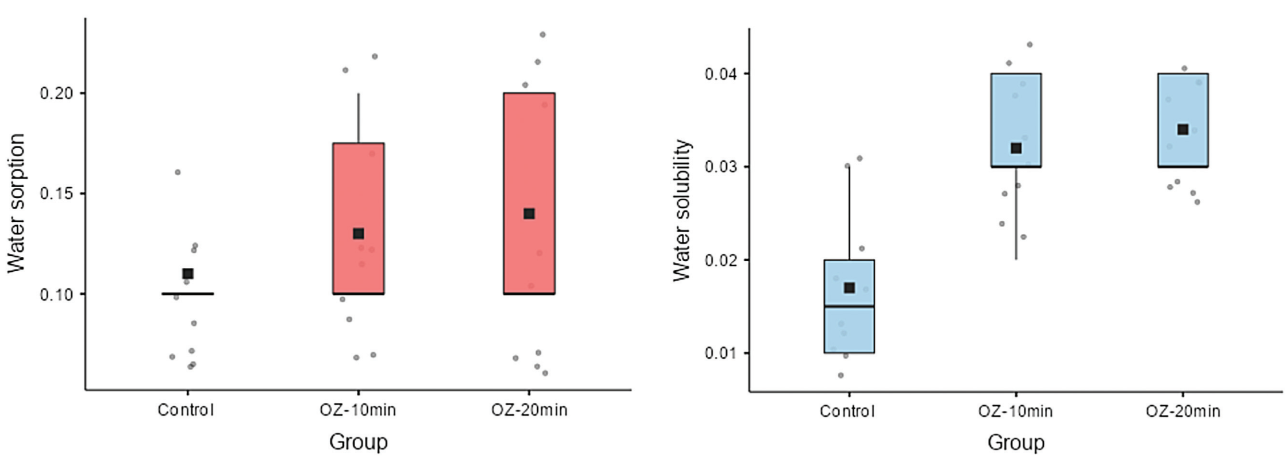

Figure 1: Box and whisker graph summarising water sorption (mg/cm^2) and water solubility (mg/cm^2) data for control, OZ-10, and OZ-20 groups.

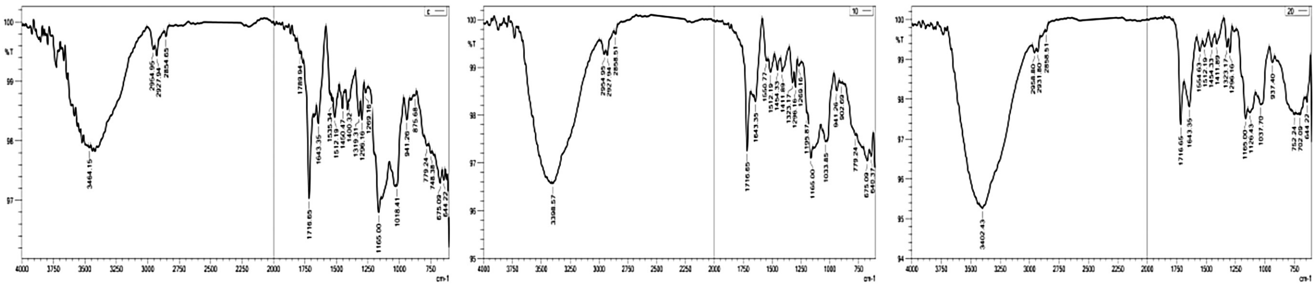

Figure 2: Fourier transform infrared spectroscopy (FTIR) data for control, OZ-10, and OZ-20 groups in order from left to right.

between OZ-10 and OZ-20 groups ($P = 0.811$). They were all within the ADA's Denture Base Standard Limit No. 12 (The absorption shouldn't be greater than 0.8 mg/cm^2, and weight loss shouldn't be greater than 0.04 mg/cm^2 for solubility) [Figure 1]. The FTIR analysis results revealed no variations between the control and experimental samples in the pattern and alignment of the absorption peaks. This means there was no chemical interaction between PMMA material and ozoneted water [Figure 2].

Discussion

The term "sorption" refers to the amount of water absorbed into the material's body as well as the amount of water adsorbed on the material's surface during the production process or while it is being renovated in service.[13] In contrast, the greatest amount of a material that may dissolve in a particular solvent at a specific temperature is known as solubility.[14]

The outcomes of the current study showed immersion of heat cure acrylic resin for 10 and 20 min in ozonated water did not affect water sorption but affected water solubility. To our knowledge, the effect of ozonated water on water sorption and water solubility of heat-cured acrylic denture base materials is rarely investigated and reported in the literature. A recent *in vitro* study by Mostafa *et al.* assessed water sorption and solubility of heat-cured acrylic resin (Acrostone) subsequent to immersing in ozonated water and normal tap water for 1 week and for 1 month. They reported a significant reduction in the water sorption and solubility after 1 week and 1 month when compared to the control group.[15] The methods of our study are similar to those of Mostafa *et al.*, yet the time of soaking is different. The concentration of ozone in our study was the concentration of 2 mg/L, and in the study of Mostafa *et al.*, it was 2–4 mg/L.

FTIR test is frequently employed to study the chemical structures and mechanisms of chemical reactions in manufactured materials and detect unstable chemicals. We chose an FTIR spectrometer in this experiment due to multiple notable advantages. Among these benefits are the much higher signal-to-noise ratio of the spectrum and the high precision of the wave number.[16] To our knowledge, this is the first attempt to assess the impact of ozonated water on heat-cured acrylic denture base materials using the FTIR test. According to the FTIR charts for control and experimental groups in this study, there is no difference in the region of bands for O–H, C–C, and C<td:glyph name=}dbnd}/>C before and after immersion in ozonated water. Consequentially, the FTIR spectra reveal that there was no interaction between ozone and heat-cured acrylic denture base materials. This may be related to the short period of immersion in ozonated water, and the ozone concentration used in this study may be another reason.

The reader should be aware that *in vitro* testing cannot accurately predict the clinical situation and that additional clinical research is required to reach definitive conclusions. Additionally, keep in mind that statistically insignificant results may be due to a small sample size.

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Conflicts of interest

There are no conflicts of interest.

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