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Article

Examining how PMMA and polyamide denture base materials' physical characteristics are affected by electrolyzed water used as a denture cleaner

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Abstract
Denture cleansing is an essential step that can stop cross-contamination and adds to the health of the patient, denture durability, and the general quality of life. A disinfection technique must be practical and devoid of damaging effects on the material's properties used to construct the denture base. The main aim of this study is to evaluate the effect of three concentrations of electrolyzed water denture cleanser on heat cure acrylic and polyamide after immersion in electrolyzed water. The evaluation is based on their efficacy on surface hardness, wettability, and color stability compared with one submerged in distilled water as a control group. The method consists of eighty samples of heat-cured acrylic and polyamide material. The samples were immersed in electrolyzed water at a concentration of (100-200ppm) and in distilled water for 5 minutes, 30 times, and daily for 12 days to simulate a one-year interval. The tests showed that the surface hardness and color stability were maintained, with no significant difference between the control and experimental groups. In comparison, the result of wettability showed a statistically significant difference between the control and experimental groups. Thus, electrolyzed water does not affect the surface hardness and color stability of heat-cure acrylic and polyamide denture base materials. However, the wettability of these materials was significantly increased.

Keywords: Electrolyzed water; Heat cure acrylic; Polyamide material

Introduction

The denture base is the portion of a denture that rests on the foundation tissues and to which teeth are attached 1. Denture base material is any material of which a denture base may be prepared [1].

Two types of material are most commonly used in the dental clinic for the fabrication of denture bases, which are thermosetting material such as polymethylmethacrylate (PMMA) and thermoplastic material such as polyamide (nylon) [2].

The presence of a removable prosthesis in the oral cavity may cause buildups of microbial plaque around and below the denture, and this may encourage specific pathological mucosal responses, denture-induced stomatitis, and angular cheilitis[3].

One of the significant factors in the etiology of denture stomatitis is the infection of the oral mucosa below a removable prosthesis by *Candida albicans* [4]. Oral candidal infection in a patient wearing dentures most commonly exists as denture-induced stomatitis [5]; this is primarily due to roughness and porosity that are considered time-related deteriorations of the denture base material, which make

the denture surface an attractive environment for the Candida albicans and other microorganisms [6]. Both Mechanical as well as chemical methods were presented to preserve denture hygiene and avoid denture-related stomatitis.
The most commonly available materials for denture cleansing are Oxygenating cleansers, mineral acids, alkaline hypochlorite solutions, pastes enzyme-containing materials, and abrasive powders [3].
The marked bactericidal activity of the electrolyzed water(HOCL) has been effectively applied in dental practice[7]. With the limits of present disinfection techniques for removable prostheses, it is worth considering the HOCL solution as a possible substitute for bio-decontaminants. These solutions demonstrate the capability to penetrate, disrupt, and remove stubborn microbial biofilm deposits, as well as having strong antiviral, antifungal, and antibacterial abilities. They are biocompatible, cost-efficient and environmentally friendly. There is no evidence of degradation or corrosion of materials exposed to modern HOCL solutions and no indication of microbial resistance to such solutions [8]. This study conducted experiments to compare the effect of HOCL disinfectant on the surface hardness, color stability and wettability in both PMMA and polyamide denture base materials.

Materials and Methods
Hundred and 80 samples were prepared: 60 samples for the surface hardness test, 60 samples for the wettability test, and 60 samples for the color stability test. Half of the samples were made of the heat cure acrylic and half of the polyamide material. They were fabricated according to the manufacturer's references. The diameter of the samples was (65x10x2.5 mm).

Preparation of electrolyzed water
Electrolyzed water can be made on-site by combining non-iodinated salt, Distilled water (D.W), and an electrolyzed water generator system (According to the manufacturer's instruction). In order to make electrolyzed water on-site, a 1-litter container was filled with D.W., to which 2 grams of non-iodized salt was added, and one teaspoonful of vinegar was added to optimize the pH. The pH was optimized using a pH meter (ISOLAB, Germany) to measure the pH of the water, and 4.5 pH was used in this study.
The system can create a concentration of (40 -200) ppm (in which 1 ppm is equal to 1mg/ L) dependent on its use, which is selected by pressing a button on the mechanism. The system has three settings as follows:

- Set 1: The device runs for 3 minutes to give electrolyzed water at 40 ppm.
- Set 2: The device runs for 5 minutes to give electrolyzed water at 60 ppm.
- Set 3: The device runs for 8 minutes to give electrolyzed water with 100 ppm.

When repeating set 3 again, it will give electrolyzed water with 200 ppm.

Immersion technique
Each specimen will be immersed in the electrolyzed water for five minutes 30 times a day for 12 days to simulate 1-year intervals, and after each immersion, the specimen will be taken out and rinsed with water and allowed to dry with absorbent papers and the process of immersion will be repeated simulating the patient denture cleaning [9].

Samples grouping
Three disinfection regimes were used for every type of resin material (heat cure acrylic and polyamide) in each test. These include:
D.W: 10 samples for polyamide and 10 samples for heat cure acrylic that is immersed in D.W.

HOCL 100PPM: 10 samples for polyamide and 10 samples for heat cure acrylic immersed in HOCL in concentration 100ppm.
HOCL200PPM: 10 samples for polyamide and 10 samples for heat cure acrylic immersed in HOCL in concentration 200ppm.

Surface hardness test
The test was performed by using a durometer hardness tester (shore D hardness) and according to ASTM D2240. The instrument indented the surface of the specimen at a load applied equal to 50N and a depressing time equal to 15 seconds. The hardness value is displayed on the device's dial scale, which is graduated from 0 to 100. Three standardized points were selected for each specimen 15 mm apart, with the average reading of these 3 points documented. The value of surface hardness of the samples was recorded after immersion of the samples of the group in the HOCL solutions in (100 and 200 ppm) concentration for (5 M) 30 times daily for 12 days and the control group immersed only in the distilled water for the same period.

Wettability test
To measure the surface wettability, a contact angle measuring device was used. To eliminate any impurities from the tested surface, all the specimens were first washed with soap and then cleaned with alcohol to eliminate any soap remains. This was followed by immersion in an ultrasonic cleanser comprising distilled water for 15 minutes and then drying it meticulously 10. To avoid the transmission of oils as well as contaminants from the skin to the samples, it must be handled with the use of forceps and gloved hands. The measuring device was linked to a computerized digital camera that captured an image after releasing a single drop of distilled water (about 10 ul volume) on the examining sample surface using a micro-syringe. The period of capturing the image was 10 seconds following placing the drop on the surface; the measurements were achieved at room temperature.

Color stability test
The device measured the amount of UV light absorption as a function of wavelength. The UV light spectrum measured was from 200nm to 400nm to measure the amount of UV light absorbed by the specimens. The disk-shaped specimens were located over the light source and exposed to light, then the readings of the absorbed light were captured from the computer’s screen attached to the spectrophotometer.

Results
This section presented the obtained results for each of the three tests experimented with in this study.

Surface hardness test
Descriptive statistics of surface hardness are shown in Figure 1, in which the (81.78) mean value was the lowest for heat-cured acrylic experimental groups, which was seen in the control group. The highest mean value (82.75) was seen in the E.W. 200ppm group, whereas the lowest mean value for polyamide experimental groups (66.94) was found in the Control group, and the highest mean value (67.46) was found in the E.W. group.

Results of the one-way ANOVA of the hardness test demonstrated no statistical difference between the groups, as shown in Figure 1.

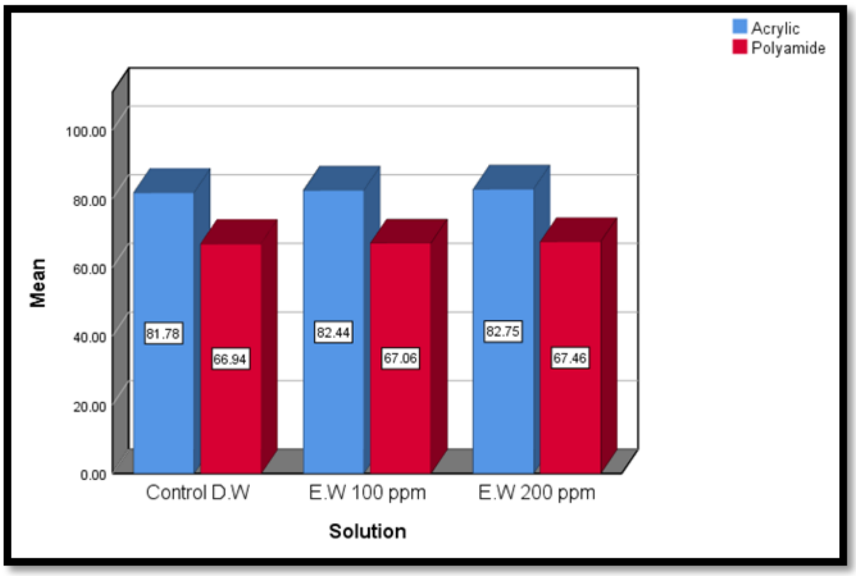

Figure 1. Bar chart of surface hardness test.

Color stability test

Descriptive statistics of the color stability test are shown in Figure 2. In this test, the lowest mean value for heat-cured acrylic experimental groups (2.32) is seen in E.W. 100 ppm, and the highest mean value (2.56) is seen in the control group. In contrast, the lowest mean value for polyamide experimental groups (1.28) was found in the E.W. 200 ppm group, and the highest mean value (1.52) was found in the E.W. group.

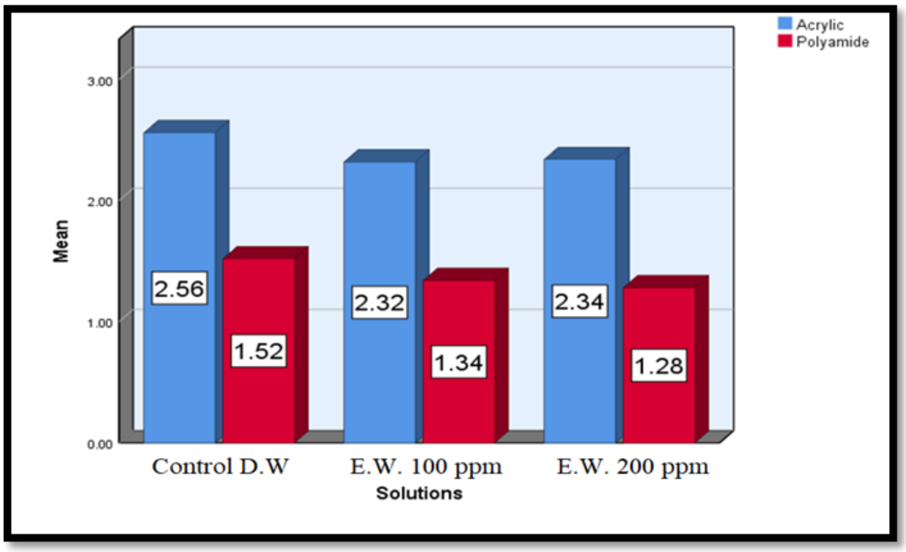

Figure 2.Bar chart of color stability test.

Wettability test

Descriptive statistics of the wettability test are presented in Figure 3. Results of the one-way ANOVA of the wettability test demonstrated a highly significance difference between the groups.

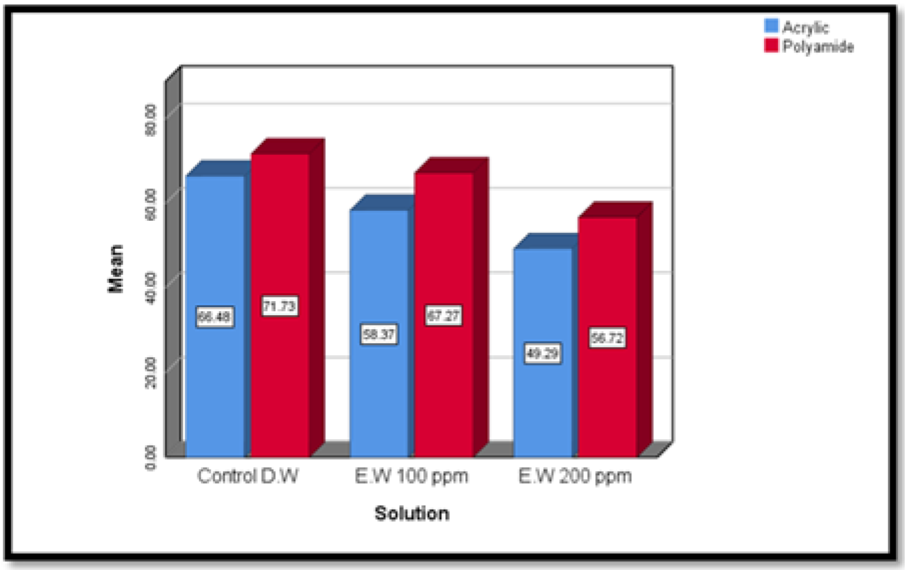

Figure 3. Bar chart of wettability test.

Discussion

The surface hardness of a material is defined as the resistance of a material to the surface penetration or indentation [11]. It is necessary to study the effect of electrolyzing water as a disinfectant on the surface hardness of the heat-cured acrylic and polyamide denture base materials. In the current study, the Shore D hardness test was used as it is a suitable one that is used for acrylic resin materials[12]. According to the statistical analysis, there was no significant difference in the hardness between the study group samples that were immersed in electrolyzing water of 100 ppm and 200 ppm concentration and the control group that immersed in distilled water for both heats cured acrylic and polyamide denture base materials with a p-value equal to (0.063) and (0.313) respectively.

Regarding heat-cured acrylic, the lack of any consequence of the immersing solutions on the surface hardness of acrylic resin might be owing to the existence of the cross-linking materials. These decrease the denture bases solubility to the organic solvents; this agreed with the study of Nimer and Jassim (2021), who concluded that immersion of heat cure specimen cured by water bath or autoclave in 1%ascorbic acid solution did not affect the tested properties of surface hardness[13].

Regarding polyamide denture base material, the result of the study disagreed with[14] that demonstrated a significant decrease in hardness following immersion of polyamide in (Corega, Protefix, Curaprox, and Perlodent) for 8 h a day for 140 days and [15] who found that Polyamide resins demonstrated low Vickers hardness after immersion for 20 days in commercially available three denture cleansers (CO-Corega, PR-Protefix, VA-Valclean) which the difference in immersion technique and different type of cleaning solutions can explain.

In the current study, regarding the difference in the hardness between heat cure acrylic resin and polyamide denture base material, there was a highly significant difference between both groups with a p-value of (0.000). Heat-cure acrylic resin has a higher hardness mean value when compared to polyamide denture base material, which agrees with 16. Different Chemical structures, techniques of polymerization, amount of cross-linking, plasticizers amount, absorption, and solubility of the denture base resins are the factors that significantly affect the

surface hardness of denture base resins[17].
The wettability of a material surface with a liquid indicates whether the material is hydrophilic (high wettability) or hydrophobic (low wettability)[10]. The contact angle is an essential parameter in the measurement of the wettability of the denture base materials. This angle is a unique feature for each substance because it relates to the surface energy of the solid substances and the surface tensions of the liquid substances. The highest is the contact angle, and the lowest is the wettability value[18].
Regarding the current study, there was a highly significant difference between control and study groups for both PMMA and polyamide, with the lowest mean value observed in the samples group immersed in 200 ppm electrolyzed water. This result was in agreement with 19, which also found a highly significant difference between polished and unpolished polyamide samples stored for 1 day in chlorhexidine and sodium hypochlorite and artificial saliva, with the lowest mean value observed in unpolished samples stored in chlorhexidine.
The increase in the surface roughness resulted in the spreading of the droplets of distilled water over a wider surface area, leading to a decrease in the degree of contact angle between the distilled water droplets and the surface area of the sample, increasing the wettability. All in 2011 mentioned that contact angle can reflect the denture materials' wettability, and it was affected by numerous factors such as surface characters, surface roughness, and temperature of the environment[20]. Regarding the comparison between PMMA and polyamide samples, there was a highly significant difference, with the lowest mean value found in PMMA group samples immersed in 200 ppm electrolyzed water. This agrees with Al's 2011 conclusion that PMMA had better wettability than Visible light cure resin, the result obtained after treatment of the samples with artificial and human saliva and propolis extract.
Numerous denture base resins have been presented that deliver easier and quicker processing. However, these materials have acceptable mechanical properties, and the color stability is also of interest, so the alteration in appearance indicates the decline in the long-term quality of a denture[21].
A spectrophotometer device is one of the most popular measurement methods or instruments used to determine the shade of dental materials in reflected or absorbed light 10.
Furthermore, there was no significant difference between polyamide samples immersed in electrolyzed water in both concentrations (100ppm, 200ppm) and distilled water. However, there was a slight change in color in both electrolyzed water groups, which can be attributed to the loss of soluble components and plasticizers from the denture base resins by denture cleansers. This result agrees with 22, who concluded that Polident and Valclean can be safely used as denture cleansers for both nylon and acrylic resin denture base materials as far as color stability and flexural strength are concerned.

Conclusions

In light of the results obtained, electrolyzed water does not affect the surface hardness and color stability of both heat cure acrylic and polyamide denture base materials. However, the wettability of these materials increased significantly. Regarding the comparison between the result of color stability between PMMA and polyamide, there was a high statistical difference, which can be attributed to the fact that PMMA has a denser color than polyamide, resulting in more absorption in UV light. Moreover, wettability is a fundamental requirement for a denture base material because it determines how easily the saliva spreads over the denture, which affects the retention of the denture. Finally, the result of the spectrophotometer study showed no significant difference between heat-cured acrylic samples that were immersed in electrolyzed water in both concentrations (100 ppm and 200 ppm) compared to distilled water.

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