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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 effective devoid of damaging effect on the materials properties used for the construction of 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, wettabilityand color stability comparing with one that submerged in distilled water as a control group. The method consists of a hundred and eighty samples of the 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 outcome of the conducted tests showed that the surface hardness and color stability were maintained, where there was no significant difference between control and experimental groups. While the result of wettability showed statistically significant difference between control and experimental groups. Thus, electrolyzed water has no effect on the surface hardness and color stability of both heat cure acrylic and polyamide denture base materials, but the wettability of these materials was significantly increased.

Keywords: Electrolyzed water; Heat cure acrylic; Polyamide material

1. Introduction

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].
There are two types of material that are most commonly used in the dental clinic for the fabrication of denture base which are thermosetting material such as polymethylmethacrylat (PMMA), and thermoplastic material such as polyamide (nylon) [2].
The presence of a removable prosthesis in the oral cavity may cause in buildups of microbial plaque around and below the denture and this may encourage certain pathological mucosal responses, denture induced stomatitis, and angular cheilitis[3]. One of the major factors that participates 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 patient wearing dentures most commonly exist as denture induced stomatitis [5], this is mostly due to roughness and porosity that 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 the denture hygiene and avoid denture-related stomatitis.
The most commonly available materials for denture cleansing is 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 to consider HOCL solution as possible substitute bio decontaminants. These solutions demonstrate capability to penetrate, disrupt and remove stubborn microbial biofilm deposit as well as having strong antiviral, antifungal and antibacterial abilities. They are biocompatible, cost efficient and environmentally friendly. There are no evidence for 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.

2. Materials and Methods

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

2.1. Preparation of electrolyzed water

Electrolyzed water can be made on-site by the combination of non-iodinated salt, Distilled water (D.W), as well as electrolyzed water generator system (According to manufacturer's instruction). In order to make electrolyzed water on-site is by filling a 1 Litter container with D.W, to which 2 grams of non-iodized salt was added and 1 teaspoonful of vinegar was added to optimize the ph. The PH was optimized by using PH meter (ISOLAB, Germany) to measure the PH of the water and 4.5 PH was used in this study.

The system has the capability to 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 run for 3 minutes to give electrolyzed water with 40 ppm.
- Set 2 the device run for 5 minutes to give electrolyzed water with 60 ppm.
- Set 3 the device run for 8 minutes to give electrolyzed water with 100 ppm when repeat set 3 once more again it will give electrolyzed water with 200 ppm.

2.2. Immersion technique

Each specimen will be immersed in the electrolyzed water for five minutes for 30 times a day for12 days to simulate 1-year interval 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].

2.3. Samples grouping

Three disinfection regimes were used for every type of resin materials (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 that immersed in HOCL in concentration 100ppm.
HOCL200PPM: 10 samples for polyamide and 10 samples for heat cure acrylic that immersed in HOCL in concentration 200ppm.

2.4. 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 load applied equal to 50N and depressing time equal to 15sec. 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 with 15 mm apart from each other with average reading of these 3 points was documented. The value of surface hardness of the samples was recorded after immersion of the samples of 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.

2.5. 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, followed by immersion in an ultrasonic cleanser comprising distilled water for 15 minutes[10]and then drying it meticulously. 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 computerize digital camera that capture an image after releasing of a single drop of distilled water (about 10 ul volume) on the examining sample surface by means of 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.

2.6. Color stability test

The device measured the amount of UV light absorption as a function of wavelength. 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.

3. Results

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

3.1. Surface hardness test

Descriptive statistics of surface hardness are shown in Figure1. in which (81.78) mean value was the lowest for heat cured acrylic experimental groups which is seen in control group and the highest mean value (82.75) is seen E.W. 200ppm group whereas the lowest mean value for polyamide experimental groups (66.94) was found in Control group and the highest mean value (67.46) was found in E.W. group.

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

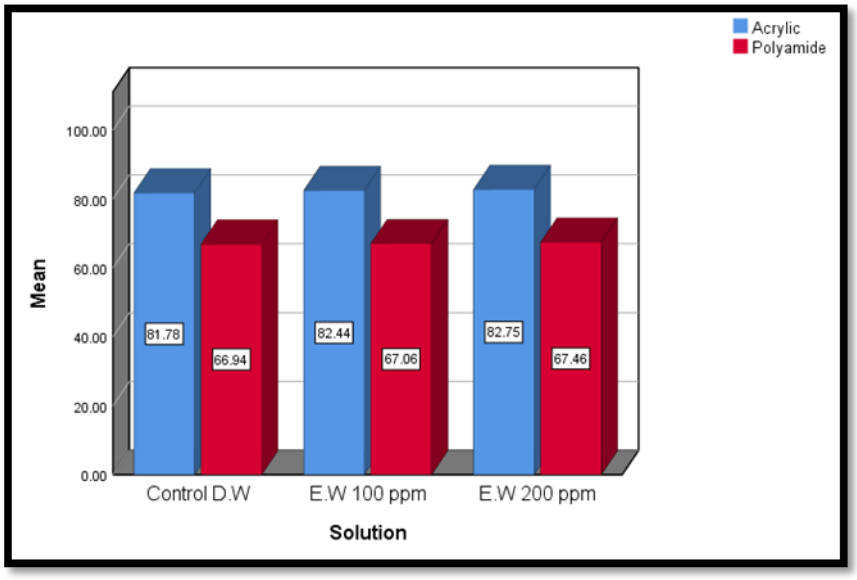

Figure 1. Bar chart of surface hardness test.

3.2. Color stability test

Descriptive statistics of 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 control group whereas the lowest mean value for polyamide experimental groups (1.28) was found in E.W 200 ppm group and the highest mean value (1.52) was found in E.W. group.

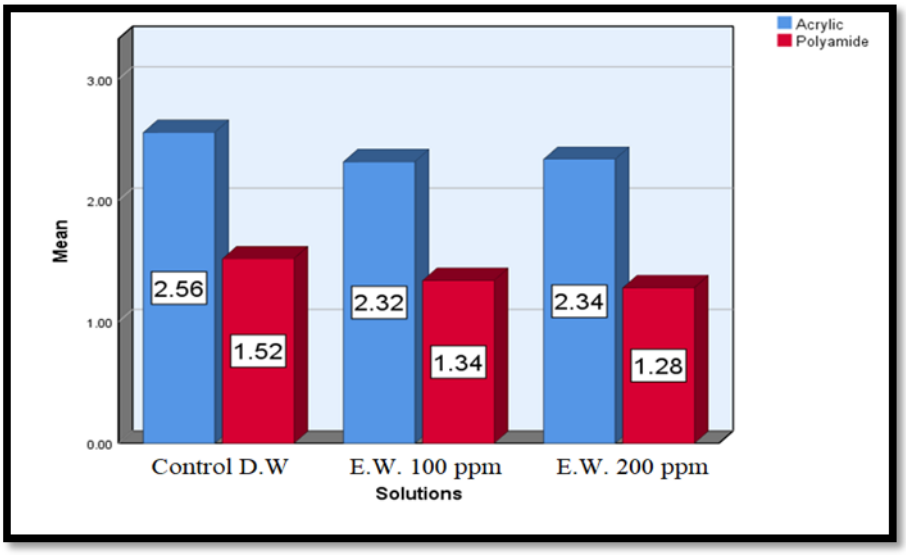

Figure 2. Bar chart of color stability test.

3.3. Wettability test

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

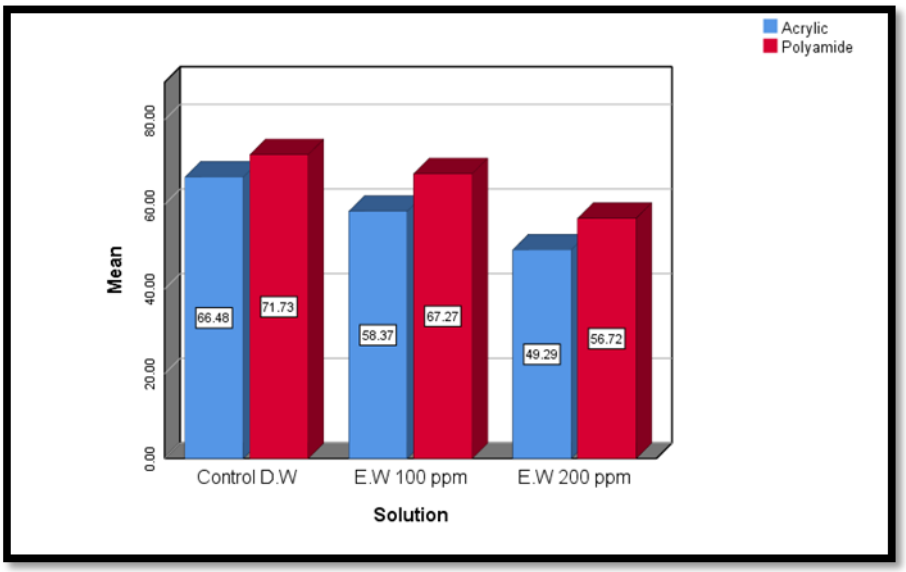

Figure 3. Bar chart of wettability test

4. Discussion

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 solution on the surface hardness of the heat cured acrylic and polyamide denture base materials. In the current study, Shore D hardness test was used as it is a suitable one that used for acrylic resin materials[12]. According to the statistical analysis there was no significant difference in the hardness between the study groups samples that immersed in electrolyzing water of 100 ppm and 200 ppm concentration and control group that immersed in distilled water for both heats cured acrylic and polyamide denture base materials with 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 withthe 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 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 can be explained by the difference in immersion technique and different type of cleaning solutions.

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 p value of (0.000). heat cure acrylic resin has a higher hardness mean value when compared to polyamide denture base material which agree with[16] . Different Chemical structures, technique of polymerization, amount of cross-linking, plasticizers amount, absorption, and solubility of the denture base resins are the factors which significantly affect the surface hardness of denture base resins[17].

Wettability of material surface with a liquid is an indication whether the material is hydrophilic (high wettability) or hydrophobic (low wettability)[10]. Contact angle is an essential parameter in the measurement of wettability of the denture base materials. This angle is a unique feature for each substance because it is related to the surface energy of the solid substances and surface tensions of the liquid substances. The highest is the contact angle 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 samples group that immersed in 200 ppm electrolyzed water and this result in agreement with[19] which also found highly significant difference between polished and unpolished polyamide samples that stored for 1 day in chlorhexidine and sodium hypochlorite and artificial saliva with the lowest mean value observed in unpolished sampled stored in chlorhexidine.

The increase in the surface roughness that resulted in 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 which mean increasing the wettability. Al in 2011 mentioned 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 result of comparison between PMMA and polyamide samples also there was highly significant difference with lowest mean value was found in PMMA group samples that immersed in 200 ppm electrolyzed water this is in agreement with Al in 2011who concluded 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, though these materials have acceptable mechanical properties the color stability also of interest so the alteration in appearance indicates decline of the long term quality of a denture[21].

Spectrophotometer device is one of the most popular measurement method or instrument used to determine the shade of dental materials in reflected or absorbed light[10] .

. Furthermore, there was no significant difference between polyamide samples that was immersed in electrolyzed water in both concentrations (100ppm, 200ppm) compared to distilled water but there was slight change in color in both electrolyzed water groups which can be attributed to the loss of soluble component and plasticizers from the denture base resins by denture cleansers. and this result in agreement with[22] who concluded that Polident and Valclean can be safely used as denture cleanser for both nylon and acrylic resin denture base materials as far as color stability and flexural strength both are concerned.

5. Conclusions

In light of the results obtained, it can conclude that electrolyzed water has no effect the surface hardness and color stability of both heat cure acrylic and polyamide denture base materials, but the wettability of these materials Increased significantly. Regarding the comparison between the result of color stability between PMMA and polyamide there was highly statistical difference which can be attributed to the fact that PMMA has already denser color than polyamide and this result 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 in turn affects the retention of the denture. Finally, the result of the spectrophotometer study showed that there was no significant difference between heat cured acrylic samples that immersed in electrolyzed water in both concentration (100ppm and 200 ppm) compared to distilled water.

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