Denture Adhesive Effects on Micro-Hardness of Polyamide Denture Base Material

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Abstract
Background The development of polymers in chemistry produces alternative materials to poly-methyl-methacrylate (PMMA) such as polyamides (nylon), acetyl resins, and epoxy resins. Polyamide denture base materials are more flexible than the commonly used (PMMA). The use of denture adhesives is suggested to achieve proper retention and stability of the removable prosthesis. Therefore, surface properties as the micro-hardness with the application of denture adhesives were recommended. **Objectives** Investigating the effect of denture adhesives on surface properties of both polyamide and heat-cured acrylic denture base material. **Materials and Methods** A total of 42 disc specimens with a diameter of 15mm and thickness of 2mm were prepared and divided into two Polyamide and heat-cured acrylic resin major groups of 21 specimens each (n=7). Each main group is subdivided into three subgroups according to the immersion process (distilled water, denture adhesive, and the control of non-immersion agent). Specimens were stored at 37°C in an incubator for the remaining 16h for 30 days. Micro-hardness was measured using a Vickers micro-hardness test under a 0.9N load for 10 seconds. The data were achieved then statistically analyzed using ANOVA and independent T-test. **Results** Among the studied groups for both heat cured and vertex denture base materials the results indicated that there were highly significant differences. The independent T-test showed that significant differences were between the tested groups for heat-cured and vertex group specimens ($P<0.01$), except that between the denture adhesives groups ($p>0.05$). **Conclusion** The results showed that the heat-cured acrylic specimens had a lower mean value of micro-hardness after immersion in denture adhesive. While the polyamide specimens had a higher mean value following the addition of denture adhesives.

Keywords: Denture adhesive; denture base material; micro-hardness; heat-cured acrylic; polyamide

Introduction

Polymethylmethacrylate (PMMA) resin has commonly used as a denture base material due to its desirable properties of excellent aesthetic properties, sufficient strength, low toxicity, low water sorption, and solubility, simple processing techniques, and easy repair. However, it has some issues, like polymerization shrinkage, lower impact strength, weak flexural, and low resistance to fatigue (O'Brein, 2008; Abuzar et al, 2010; Vivek, 2016). Recently, thermoplastic resins like polyamides or nylons became a common substitute to PMMA resin because of their appropriate chemical and physical characteristics (Al-Dharrab and Shinawi, 2016; Shinawi, 2017; Ozyilmaz and Akin, 2019) Such materials are biocompatible and have unique aesthetic and physical properties that offer unlimited design versatility and eliminates the concern regarding acrylic allergies (Lowe, 2004; Mekkawy et al, 2015). Nylon based (polyamide) is a flexible material of dental base characterized by its flexibility, nearly unbreakable, pink in color resembling gum, and can form the denture base and clasps with quite thin built. Besides that, it's lightness in weight gives comfort to the patient. The thermoplastic material has a special character of not chemically bond, but mechanically with any of porcelain or acrylic materials (Prashanti et al, 2010; Kurt et al, 2012; Al-Takai, 2014; Shah et al, 2014). Denture adhesive material utilizes to assist the adherence of a denture to the oral mucosa (Dent, 2005; Pachore et al, 2014). As they are properly used, they provide benefits to the patients in improving denture fitting, comfort, psychological security, and functional efficiency (Shankar, 2010; Fernandez et al, 2016). Although the denture adhesives significantly improve the patient confidence and performance of removable denture; their uses should not be considered to compensate for the defects of denture prosthesis. Therefore, the patient should use the denture adhesive only on dentist advice. On the other hand, the dentist should provide the patient with full instructions regarding precautions and the right usage of denture adhesives (Kumar et al, 2015; Ibraheem and Hammad, 2019). Denture adhesives came in different forms as soluble adhesives pastes, powder, and creams, and also as insoluble adhesives like. strips (Pradies et al, 2009, Chowdhry et al, 2010; Sampaio-Maia et al, 2012; Ibraheem and Elsisy, 2019). The denture adhesives should be non-irritant, non-toxic, odorless, biocompatible with the oral mucosa, and tasteless. They also should retain the adhesive properties for 12-16h, in addition to not enhancing the microbial growth (Sampaio-Maia et al, 2012; Duqum et al, 2012). Denture adhesive or soft lining materials might be used to a certain degree for patients with denture stomatitis (Kim et al, 2003). The water absorption as well as the porosity of such materials could affect the surface hardness inferiorly (Azevedo et al, 2005; Utami et al, 2009; Golbidi and Asghari, 2009). Surface micro-hardness may provide an impression regarding the density of any material since dense substances frequently should have a high resistance to superficial weariness (Jo et al, 2011; Ibraheem and Hammad, 2019). There were few published studies regarding the denture adhesives effect on the micro-hardness of thermoplastic polyamide flexible base material and heat-cured acrylic resin. Therefore, this study was performed to evaluate the effect of denture adhesive on the surface micro-hardness for both polyamide and heat-cured acrylic denture base materials.

Materials and Methods

Material

In this study, the Fittydent cream was utilized (Austria). The thermoplastic injection molded for flexible resin (vertex, Netherlands) and heat-cured acrylic were used as well, (vertex, Netherlands).

Specimen fabrication

A total of 42 disc specimens of 15×2 diameter and thickness respectively were prepared using a metallic matrix to create the specimens wax patterns as shown in figure (1), (Goiato et al, 2010). Two main groups for Polyamide and heat-cured acrylic resin were subdivided into 3 subdivisions (n=7) according to the immersion process in either distilled water, denture adhesive, or the non-immersion group (control). The PMMA specimens were fabricated according to the manufacturer's instructions regarding both molding and thermo-pressing techniques. After the thermo-injecting process, the flasks cooled down for 15min at room temperature. Then, they deflasked and finished as shown in figure 2 (A and B). The prepared disc study specimens checked for the absence of any nodules, bubbles, or porosity, and those observed with defects were discarded. Before the testing procedure, the specimens were stored in distilled water at 37°C for 7 days for residual monomer elimination. Finally, all the specimens were dried, finished, polished, numbered, and labeled.

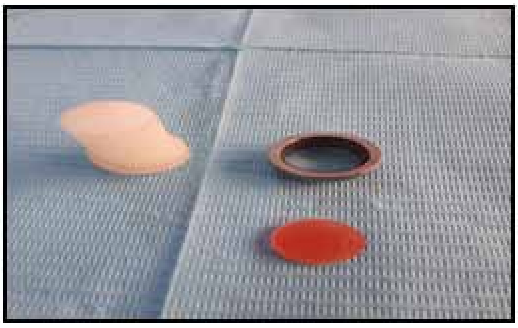

Figure (1): Metal mold for wax disc specimen fabrication.

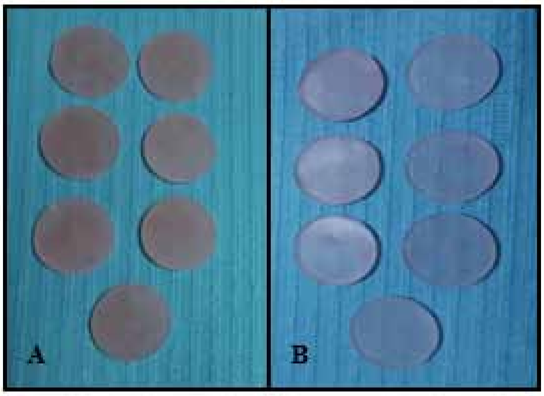

Figure (2): A. Heat-cured specimens. B. Vertex specimens.

Denture adhesives preparation

According to the pilot study, the prepared denture adhesive material (Fittydent Cream) was diluted with distilled water by a ratio of 1g/6ml in a closed glass tube, at a pH of 5.6 using a pH meter. Each specimen was individually immersed in glass containers containing distilled water, the immersion time was 16h/day, and stored in an incubator at 37°C, next rinsed under running water, then dried gently. After that, specimens were stored in distilled water for 8h at room temperature, and the distilled water was changed every day for up to 30 days. The procedure was applied for the diluted adhesive material and for 30 days as well. Finally, the micro-hardness for each group of specimens was measured (Ibraheem and Hammad, 2019).

Micro-hardness test

A digital micro Vickers hardness tester was utilized to measure the micro-hardness. A load of 0.49N for 10 seconds was applied for all specimens (Goiato et al, 2010). Each specimen was gently dried and then three indentations were made and the average was calculated for each specimen. The first reading was immediately achieved after specimens› preparation, while the second measured after 30 days of immersion procedure.

Statistical analysis

Statistical analysis was performed with the SPSS statistical package. The mean, standard deviation, and standard error of micro-hardness data for the study groups were calculated using descriptive data analysis. Furthermore, the comparison was performed using the Student`s t-test.

Results

The results indicated that the highest mean value of hardness was obtained in the control group while the lowest mean value was in the adhesive group as illustrated in Table (1), and Figure (3). One-way ANOVA test demonstrated a highly significant result among some studied groups. Highly significant differences were reported between the control group and that of adhesive group, and the distilled groups, and that of the adhesive group ($p<0.01$). In contrast, no significant differences were observed between the control group and that distilled group ($p>0.05$) as shown in (Table1). For Flexible materials, the greatest mean value was obtained in an adhesive group of (11.951) whereas the lowest mean value was in the control group as presented in Table (1), and Figure (3). No significant differences were noticed between the control and distilled groups (p-0.05). In contrast, highly significant differences were observed between the control group and that of the adhesive group ($p<0.01$). In addition to the above observations, significant differences ($p<0.05$) were shown between distilled and that of the adhesive group as shown in the LSD test Table (1).

Table (1): ANOVA- LSD test showing the micro-hardness of the experimental groups.

LSD test (P-value)						
Studied groups		Micro-hardness				
		Heat	Sig.	Vertex	Sig.	
Control group	Distilled water group	P=0.976	NS	P=0.557	NS	
	Adhesive group	P=0.00	HS	P=0.006	HS	
Distilled water group	Adhesive group	P=0.00	HS	P=0.024	S	

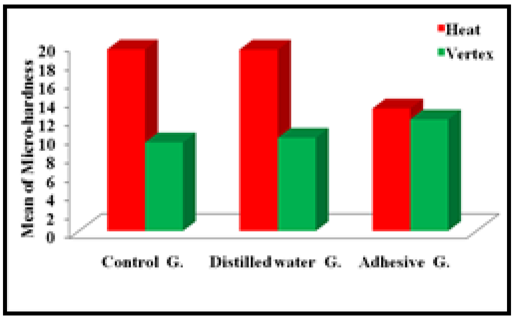

Figure (3): Mean value of micro-hardness for heat and vertex denture base material.

Discussion

Denture adhesive provides relief and additional trust for the patient and that by increasing the adhesive and cohesive and decreasing the void which may be observed between the denture base and the underlying ridge (Pachore et al, 2014). Kumar et al, (2015) stated that the cushioning effect of denture adhesives reduced the pressure and friction transmitted to the underlying mucosa. The surface hardness of flexible denture base materials is important because their durability, serviceability, and longevity are affected during function (Shah et al, 2014). Polymer surface micro-hardness had been investigated using different in vitro methods (Ibraheem and Hammad, 2019). The result of this study showed that there were highly significant differences in surface micro-hardness of both heat-cured acrylic resin and polyamide denture base material before immersion, at the baseline or the control group. Higher hardness value was observed to the conventional acrylic resin of the control group in comparison to polyamide and this may be attributed to the higher fiber content and low elastic property in contrast to the conventional type (Shinawi, 2017). The result is coinciding with Utami et al, (2009) when they reported in their study that the micro-hardness of nylon resin is less than that of the PMMA. One of the causes for this result is probably the porosity; this may in line with Illmide that indicated thermoplastic nylon resin porosity higher than heat-cured acrylic resin. The mean value of micro-hardness for both types of acrylic resin revealing a high-significant difference in distilled water and this result for heat-cured PMMA. This could due to the cross-linking material that enhances the surface hardness and reduces the water absorption amount of denture base. Polymeric dental material is characterized by water sorption phenomenon which decreases their surface micro-hardness as a result of excessive hydration debonding their filler matrix and also the absence of cross-linking biofunctional resin that could enhance the softening effect of the solvent (Mekkawy et al, 2015; Ibraheem and Hammad, 2019). The present study results may in agreement with the work of Utami et al, (2009) who concluded that the micro-hardness of nylon polyamide resin was less than the PMMA. The two- days soaking in water is intended to find out the effect of water absorption on surface hardness nature in polyamide nylon resin and the PMMA resin. This is the possible reason to describe the reduction of surface hardness of acrylic resin after soaking in water, as it gives a plasticizer effect to the resin. Lower surface hardness in the nylon resin compared to PMMA resin after two-days of soaking was affected by the higher porosity in the thermoplastic nylon resin. On the other hand, a non-significant difference was observed in mean values of surface micro-hardness after immersion in denture adhesive when compared between both the heat-cured and polyamide resin denture base material. Since the hardness of heat-cured acrylic resin was decreased after immersion in diluted denture adhesive solution, this could be attributed to monomer leak out from resin matrix and/or the molecules diffuse from solution into resin and form aside group chain. These two chemical reactions of diffusion and leaching out result in the softening of the resin (Shinawi, 2017). While micro-hardness of polyamide increased after immersion in denture adhesive and this may be an outcome from the condensed polymerization of nylons resin giving an aliphatic chain which is free from cross-linking and with a complex crystalline molecular structure of nylon matrix that prevents the entrance of the molecules into the nylon matrix (Shinawi, 2017). The current results may disagree with Ibraheem and Hammad, (2019) who found that a decrease in micro-hardness values of flexible denture base material after the immersion for one month, and in two different denture adhesives. And this could be attributed to a liquid/powder ratio which is the monomer/polymer ratio with the presence of such cross-linking agent (methyl-methacrylate) will affect surface hardness.

Conclusion

After one month of immersion in denture adhesive, the micro-hardness of heat-cured acrylic was decreased while it increased for polyamide denture base material.

Conflict of interest

We are the author's (Hanan Qassim Hassan and Amaal Khadim Mohammed) state that the manuscript for this paper is original, and it has not been published previously, and it is part of the MSc. dissertation and is not under consideration for publication elsewhere, and that the final version has been seen and approved by all authors.

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