J Biochem Tech (2019) Special Issue (2): 106-112
ISSN: 0974-2328

Evaluation of the Effect of Two Denture Disinfectants on the Surface Roughness of Conventional Heat-Cured Acrylic and TiO2-Reinfirced Acrylic Resins

Elnaz Moslehi Fard, Tahereh Ghaffari, Khosro Zarei*

Received: 19 February 2019 / Received in revised form: 12 April2019, Accepted: 22 April 2019, Published online: 25 May 2019

Abstract

Background and objective: Chemical solutions are used to disinfect the teeth. They are usually used in combination with mechanical methods. Studies indicated that chemical solutions have a major role in the removal of microorganisms and microbial plaques. However, they cause physical and mechanical changes in acrylic resins such as changes in color, hardness and roughness of surface. Increasing surface roughness over time will increase the microbial and food particles adhesion to the acrylic surface, resulting in irritation and inflammation of the oral mucosa. Adding 1% TiO2 to acrylic can improve its properties. The objective of this study was to evaluate the effect of two denture disinfectant agents on the surface roughness of conventional acrylic resin and TiO2-reinfirced acrylic resin. Methodology: This research was a In-vitro study. The samples of this research included 60 acrylic resin samples in 2 groups (each group included 30 samples) and each group included 3 sub-groups (10 samples in each subgroup). Resin samples were made with heat-cured acrylic reinforced with 1% TiO2. They were immersed in three solutions of water, solution prepared with NatureDent tablet, and1% sodium hypochlorite for three periods of 30, 60 and 90 days. The disinfectant solution was replaced each day and this process was repeated. Then, the samples were washed with distilled water and placed in a container filled with distilled water to ensure uniformity of storage conditions. Then, the surface roughness test was performed on each sample. The data were analyzed using descriptive statistical methods and two-way ANOVA, one-way ANOVA, T-test and Tukey HSD test and through SPSS.17 statistical software. In this study, p value less than 0.05 was considered significant. Results: a significant difference was seen in surface roughness on the days 1, 30, 60 and 90, and the statistical value of 0.00 was reported in all 4 periods. By changing the type of disinfectant, the statistical value of the test on the day 1 and 30 did not show significant difference($p>.05$). However, this value was reported 0.00 on the days 60 and 90, indicating a significant change in surface roughness($p <.05$). In examining the simultaneous effect of resin type and disinfectant type, the statistical value of the test on the day 1 ,30 and 60 did not show significant difference($p>.05$). However, on the day 90, indicating a statistically significant difference($p <.05$). Moreover, the results showed that the rate of increase in sodium hypochlorite solution was higher than that of NatureDent and the rate of change in roughness in 1% TiO2-reinforced acrylic resin was less than that of conventional acrylic resin. Conclusion: By adding 1% TiO2 to heat-cured acrylic, the denture resistance to the change in surface roughness versus two solutions of sodium hypochlorite and a NatureDent disinfectant tablet can be increased. In addition, with increasing of time, the effect of the type of disinfectant solution on the roughness increases. This effect is lower in TiO2-reinfirced acrylic resin that in conventional acrylic resin.

Keywords: Denture, Heat-cured acrylic, TiO2, Surface Roughness.

Introduction

Hand and teeth health cares are very important in maintaining the health of oral mucosa (Shay, 2000). These cares become more difficult in the elderly people due to illness as well as reduced skill. Regardlss of beauty, lack of observing the health creates biofilm which finally causes inflammation of the oral mucosa (Kulak-Ozkan, Kazazoglu and Arikan, 2002). The mechanical method is one of the most common methods for removing biofilms from the denture surface. Chemical solutions are used to disinfect the hands and teeth. They are commonly used in combination with mechanical methods (Paranhos et al., 2007). The conducted studies suggest that chemical solutions play a major role in the removal of microorganisms and microbial plaques, but they cause physical and mechanical changes of acrylic resins such as color changes and surface roughness. Increasing surface roughness increases the microbial adhesion and food particles adhesion to the acrylic surface over time, leading to irritation and inflammation of the oral mucosa (Ebadian, Poorsina and Saghaei, 2007). There are several reasons for causing surface roughness by acrylic resins. One of the reasons is disinfectants. Many studies have been conducted so far on the effects of disinfectants on surface changes in acrylic resins and the creation of surface roughness, but

Elnaz Moslehi Fard, Tahereh Ghaffari
Associate professor, Department of prosthodontics, Faculty of Dentistry, Tabriz University of Medical sciences, Tabriz, Iran.

Khosro Zarei
Postgraduate student of prosthodontics, Department of prosthodontics, Faculty of Dentistry, Tabriz University of Medical sciences, Tabriz, Iran.

***Email:** khosro.z.31@gmail.com

acrylic resins and immersion times need to be examined, givn the diversity of substances (Shen, Javid and Colaizzi, 1989).

Flavio and Lara (2012) examined the effects of disinfectant compositions with hypochlorite base and peracetic acid on the physical properties of heat-cured resins. A total of 60 acrylic resin samples were placed in two solutions of 1% sodium hypochlorite and 2% peracetic acid. Then, the surface roughness and acrylic color changes were evaluated. Based on the results, the surface roughness and color changes increased in all samples after 30 and 60 minutes of immersion (Fernandes, Orsi and Villabona, 2013). In another study conducted by Nematollahi et al in 2014 under the title of "Evaluation of the effect of four chemical disinfectants on surface roughness of acrylic resin denture base, it was concluded that the effect of disinfectant on the surface roughness of Meliodent acrylic was higher than Acropars, and the lowest effect related to effect is on the Corega tablet (Nematollahi et al., 2014). Pisani and Macedo (2012) evaluated the effect of two denture disinfectants on the properties of acrylic resin teeth. A total of 30 samples of 3 resin teeth (Vipi, Biolux and Trilux) were immersed for 183 times and 15 days in water solution, 1% Sodium Hypochlorite and 2% Ricinus communis (RC).

Results showed that the Biolux group had the highest surface roughness after 183 times of immersions (Pisani et al., 2012). Daniela and Leticia (2001) examined the effect of 5 denture cleaners, including Periogard (PE), Cepacol (CE), Corega Tabs (CT), Medical Interporous (MI), Polident (PO), 0.05% Sodium Hypochlorite and distilled water (DW) as the control group on the surface properties of removable partial denture. They concluded that acrylic resin surface roughness does not change significantly in these cleaner solutions (Felipucci et al., 2011). Heat-cured acrylic is the most widely used in denture base construction, but it has some disadvantages. Hence, various methods have been used to increase the strength of denture materials, including the use of polymethylmethacrylate / TiO2. The result of the study conducted by Shirkavand et al under the title of "evaluation of the effect of TiO2 Nanoparticles on the tensile strength of acrylic resins" showed that the tensile strength increases in acrylics with 1% ws TiO2 nanoparticles, as reinforcing materials, and increasing the TiO2 nanoparticles more than this level reduces the tensile strength (Shirkavand and Moslehifard, 2014). In a study conducted by Kado et al, they examined the cleaning effect of TiO2-reinforced acrylic resin. They concluded that reinforcing acrylic resin with titanium dioxide (TiO2) had a positive effect on the ease of cleaning the resin by preventing the accumulation of bolus as laboratory residue (Kado et al., 2005). In a study conducted by Pinto et al on the effect of repeated and prolonged use of sodium hypochlorite disinfection on the surface roughness and hardness of acrylic resins, it was concluded that surface roughness significantly increased and its hardness decreased after 180 times of immersion in a hypochlorite solution sodium (Pinto et al., 2014).One of the main concerns in the removale prosthesis made of acrylic resin is the physical and mechanical changes of acrylic resin denture base. Moreover, health care and disinfection are essential in each stage of dentistry practices. Given the inconsistencies in the results of various studies and the prevalence of the use of chemical compounds in the cleaning of dentures by patients as well as the lack of investigating these cases in heat-cured acrylics and TiO2- reinforced acrylics, the present study was conducted to investigate the effect of two chemical disinfectants on the surface roughness of conventional acrylic and TiO2- reinforced acrylic at the Dentistry Faculty of Tabriz University of Medical Sciences during the academic year of 2017-2018.

Methodology

Heat-cured acrylic resin samples (SR Triplex Hot, Germany, Liechtenstein, Ivoclar vivadent) with 20x20 mm dimensions were mixed according to the manufacturing company guidelines. After being prepared, they were compressed. In order to be cured, the set was placed in a water bath and kept in boiling state for 45 minutes. Then, the outer surface of the obtained samples was polished with 100,200 and 400 grit silicon carbide paper, respectively (Made by STARCKE in Germany Matador Brand). In order to make TiO2-reinforced acrylic resin, the powder of denture base Poly methyl methacrylate was mixed with TiO2 particles with 1% weight percentage in the ultrasonic apparatus to obtain a homogeneous mixture. The samples were flasked and cured according to the manufacturer company guidelines. To ensure uniform distribution of nanoparticles, samples were examined before mechanical tests by SEM scanning electron microscopy (Phenom, Model ProX, Eindhoven, Netherlands). Each group of samples was stored in distilled water at 37 ° C for 48 hours, according to the standards of ADA and ISO (International Standards Organization). In this study, two chemical disinfectant solutions of 1% sodium hypochlorite and a solution prepared from NatureDent tablet were used for immersion. The samples were divided into two groups based on the type of acrylic resin and each group were randomly divided into 3 sub-groups (each subgroup included 10 samples).

1. The first subgroup was considered as control and it was kept only in water.
2. The second subgroup were kept at 1% sodium hypochlorite solution (containing 100 cc sodium hypochlorite containing) (Iran, Robat Karim, Golrang, Sodiumhypochlorite) for 2 minutes in cycles of 30, 60 and 90 days.
3. The third subgroup was kept at solution prepared with NatureDent tablet (NatureDent, FITTYDENT, Vienna, Austria) for 10 minutes in cycles of 30, 60 and 90 days.

The immersion procedure was in this way that each sample was placed inside the considered disinfectant solution in a room for 2 (Phoenix et al., 2008) or 10 minutes (depending on the disinfection solution). Then, the disinfectant solution was removed and washed. Then, the samples were placed in the distilled water and distilled water was replaced between the cycles. Each day, the disinfectant solution was replaced and this process was repeated. This process was done at intervals of 30, 60 and 90 days. After performing these

steps, the samples were washed with distilled water and placed in a container filled with distilled water to ensure uniformity of storage conditions until the test was performed.

In order to investigate surface roughness in this study, a roughness meter of TIME Company (TR200 Lenexa, USA) was used. The obtained data were analyzed by descriptive statistical methods (mean, standard deviation, percentage frequency) and two-way ANOVA test to investigate the effect of two variables (acrylic type, disinfectant type) and one-way ANOVA test was used to evaluate the effect of each of the variables and T-test was used to compare the two types of acrylics and the Tukey HSD Test was used for ranking the variables. The SPSS.17 software was used for statistical analysis. In this study, p value less than 0.05 will be considered significant.

Results

Figures 1 and 2 show the images prepared by scanning electron microscopy of samples made with conventional acrylic and acrylic reinforced with 1% TiO2 powder. As indicated in the figure, TiO2 powder in acrylic is uniformly distributed.

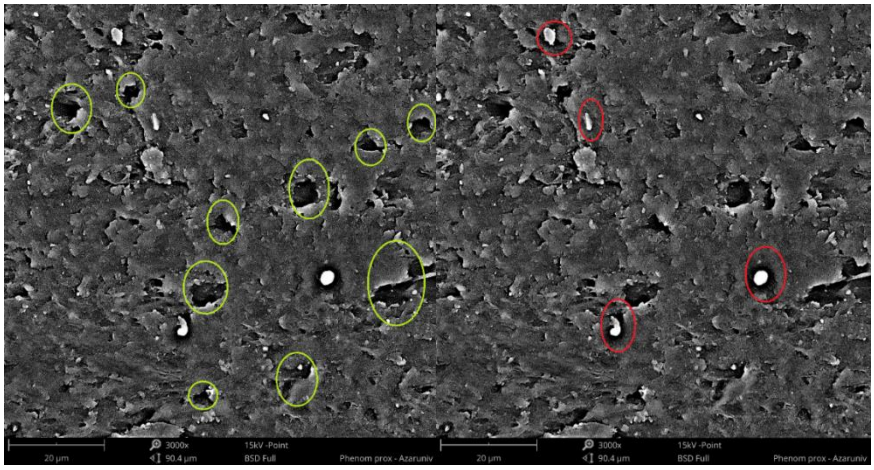


Fig. 1: (a) SEM image of conventional acrylic sample. **(b)** Superficial cavities in conventional acrylic sample

Figure 1 (a) is relates to conventional acrylic. The areas shown with the red circle are related to the electron charge. That is, the accumulation of electrons related to electron microscope is high. In this area, Ti is zero.

The areas shown in Figure 1 (b) with a green circle are related to the surface cavities of the sample, which is related to way of its construction.

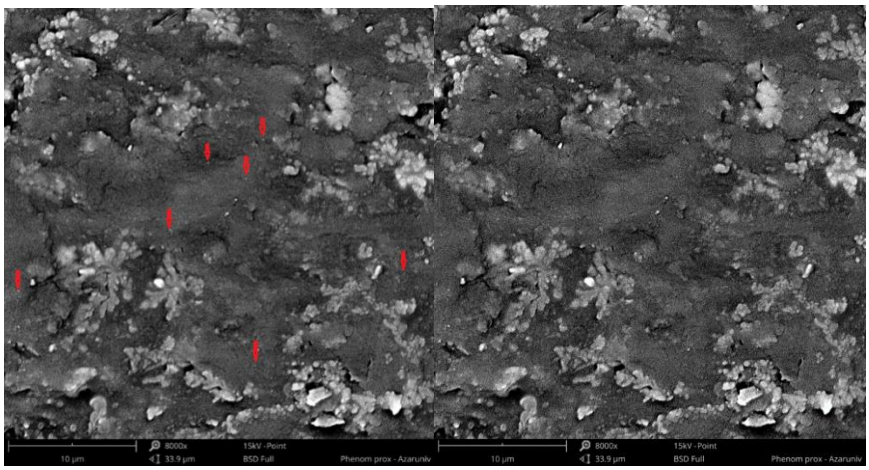


Fig. 2: (a) SEM image of acrylic sample with 1% titanium dioxide. **(b)** TiO2 particles distributed on the sample surface

Figure 2 (a) is related to the sample containing TiO2 particles.

The points shown in Figure 2 (b) with a red arrow are related to portion of the TiO2 particles dispersed at the surface of the sample.

First, data on testing the roughness in water, roughness of sodium hypochlorite solution and roughness of disinfectant NatureDent tablet were evaluated and they showed normal distribution.

Table 1- Two-way variance analysis to investigate the effect of type of acrylic (conventional acrylic and TiO2-reinforced acrylic) and solution type (water, sodium hypochlorite and NaturDent) on roughness in 4 time periods

	Source of change	Day 1		Day 30		Day 60		Day 90	
		F	P value	F	P value	F	P value	F	P value
Roughness	Resin	100.09	0.000	107.51	0.000	122.53	0.000	149.98	0.000
	Solution	0.24	0.791	1.83	0.170	10.69	0.000	34.28	0.000
	solution ×resin	1.05	0.356	1.29	0.284	1.97	0.149	3.38	0.041

Two-way analysis of variance shows that roughness is significantly different based on acrylic type and solution type ($p < .05$). The comparison of the mean roughness (Table 2) has been investigated in each of the main effects.

Table 2- Comparison of mean roughness in two types of acrylics and three types of solutions in four time periods

time	Solution	Conventional acrylic		1%TiO2		p value*
		mean	SD	mean	SD	
Day 1	water	0.946	0.076	0.772	0.068	0.000
	Sodium hypochlorite	0.974	0.067	0.761	0.062	0.000
	NatureDent	0.949	0.074	0.799	0.068	0.000
	p value	0.642		0.428		
Day 30	water	0.946	0.076	0.772	0.068	0.000
	Sodium hypochlorite	1.012	0.070	0.783	0.063	0.000
	NatureDent	0.975	0.076	0.813	0.068	0.000
	p value	0.155		0.375		
Day 60	water	0.946^{b}	0.076	0.772	0.068	0.000
	Sodium hypochlorite	1.093^{a}	0.077	0.831	0.067	0.000
	NatureDent	1.034^{a}	0.080	0.840	0.072	0.000
	p value	0.001		0.075		
Day 90	water	0.946^{c}	0.076	0.772^{c}	0.068	0.000
	Sodium hypochlorite	1.203^{a}	0.082	0.905^{a}	0.073	0.000
	NatureDent	1.128^{b}	0.087	0.871^{b}	0.073	0.000
	p value	0.000		0.001		

P value: One way ANOVA

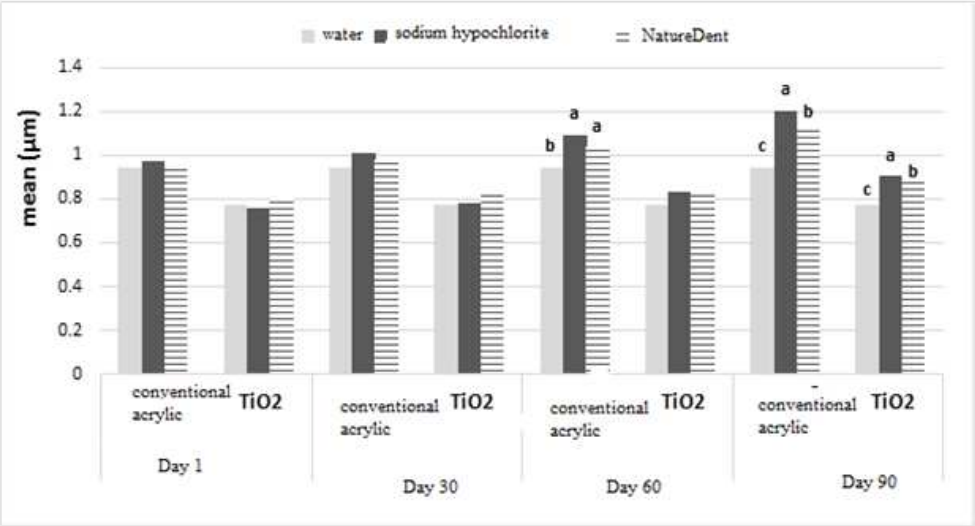
P value*: Independent T Test

a,b,c: Tukey HSD Test (similar letters represent non-significance)

The results of Table 2 and T-test showed that in each of the four times (days 1, 30, 60 and 90) and in each of the three solutions (water, sodium hypochlorite and NatureDent), the TiO2-reinforced acrylic roughness is significantly less than conventional acrylic ($p < .05$).

The results of ANOVA test show that:

- On the days 1 and 30, roughness was similar in three types of solutions of water, sodium hypochlorite, and NatureDent in both conventional acrylic and reinforced acrylic and there was no significant difference.
- On day 60, in the conventional acrylic, roughness was similar in sodium hypochlorite and NatureDent solutions and it is significantly lower in water samples ($p < .05$). However, in TiO2-reinforcd acrylic, the roughness of the three solutions is similar.
- On day 90, in both types of conventional acrylic and TiO2-reinforcd acrylic, roughness was at minimum in water samples ($p < .05$) and at the maximum in sodium hypochlorite samples ($p < .05$). Roughness in the NatureDent samples ranked second ($p < .05$).
- In each of the days 1, 30, 60 and 90, the level of roughness in TiO2-reinforced acrylic samples is significantly less than that of conventional acrylic ($p < .05$).



a,b,c: Tukey HSD Test (similar letters represent non-significance)

Chart 1: The comparison of the mean roughness in two types of acrylics and three types of solutions in the four time periods

Discussion

Surface roughness of the denture materials is very important since it can directly or indirectly affect the binding of microorganisms (Berger et al., 2006). The denture surface irregularities, especially the tissue surface, can facilitate the binding of microorganisms. The change in surface roughness of the acrylic resin denture base when exposed to denture cleaners has been reported in studies (da Silva et al., 2008), but the effect of denture cleaners on the properties of acrylic resins after long immersion periods has not been studied extensively (Pisani et al., 2012). The cumulative effect of disinfectants over time can leave its negative effect on mechanical and surface properties of acrylic (Nematollahi et al., 2014). Therefore, in the recent study, the times of days 30, 60, and 90 was considered for placement of the samples in the disinfectant solutions. In this study, the effect of 2 types of disinfectants, including 2% sodium hypochlorite and NatureDent and water on surface roughness of acrylic resins was studied. The results showed that the use of chemical disinfectants of 1% sodium hypochlorite and NatureDent tablet for disinfecting the heat-cured acrylic resins increases their surface roughness. Based on the results obtained from the roughness test, it can be stated that conventional heat-cured acrylic samples and 1% TiO2-reinforcd acrylic samples in water do not change in different periods of time and the level of roughness remains fixed. It suggests that the considered denture surface does not react with water. By examining the conventional heat-cured acrylic samples and 1% TiO2-reinforcd acrylic samples in solution prepared with NatureDent tablet and measuring their surface roughness, it was revealed that the level of surface roughness increased in both types of samples ($p < .05$). The rate of this increase was higher for both types of denture in each period than that in the previous period. However, the rate of change in roughness in 1% TiO2-reinforcd acrylic samples was lower than that of conventional heat-cured acrylic samples, which indicates the effect of the presence of TiO2 as a denture reinforcing phase, which increases the resistance to the effect of NatureDent solution.

Moreover, by examining conventional heat-cured acrylic samples and 1% TiO2-reinforcd acrylic samples in 2% sodium hypochlorite solution and measuring their surface roughness, it was revealed that the surface roughness increased in both types of samples ($p < .05$). The rate of this increase was higher for both types of denture in each period than that in the previous period. However, the rate of change in roughness in the 1% TiO2-reinforcd acrylic samples was lower than that of conventional heat-cured acrylics, indicating the effect of the presence of TiO2 as a denture reinforcing phase, which increases the resistance to the effect of NatureDent solution. The rate of the effect of sodium hypochlorite solution on the roughness of the samples is more than that of the NatureDent solution. In the study conducted by Ebadian et al on the effects of sodium hypochlorite and glutaraldehyde on two types of acrylics, including Acropars and Meliodent, showed that sodium hypochlorite caused more changes than glutaraldehyde (Ebadian, Poorsina and Saghaei, 2007).

Paranhos et al in 2009 investigated the physical and mechanical properties of microwave-polymerized acrylic resins after immersion in 1% sodium hypochlorite solution and Corega tablet and they concluded that immersion of samples in 1%sodium hypochlorite and Corega tablet during 180 days have a significant change in surface roughness, which is in contrast to the results of the present study. This difference might be due to the difference in the type of acrylics and type of polymerization as well as in the duration of the study (Paranhos et al., 2009). Sharma et al (2017) examined the effect of denture cleaners on surface roughness and flexural strength of heat-cured acrylic resin denture base. A total of 40 acrylic resins were immersed in 3 cleaning solutions (1% sodium hypochlorite, FittyDent tablet and 100% vinegar) daily for 90 days, and the results showed that after 90 times of immersion in sodium hypochlorite solution, surface roughness increased significantly, which is consistent with the results of the recent study (Sharma, Garg and Kalra, 2017).

Porwal et al (2017) examined the effect of denture cleansers on color stability, surface roughness and hardness of acrylic resin denture base. A total of 60 samples of 3 different resin materials (conventional heat-cured acrylic resin, high impact resin and polyamide denture base resin) were daily immersed in 2 solutions of 0.5% hypochlorite and 3.8% sodium perborate for 180 days. The obtained results indicated that the conventional heat-cured acrylic resin immersed in sodium hypochlorite solution showed the highest change in the roughness, which is consistent with the results of this study (Porwal et al., 2017).

Machado et al in 2009 examined the effects of frequent disinfection methods with immersion in sodium perborate and microwave waves on the surface roughness and hardness of acrylic resin denture base and two types of chairside reline resin (Kooliner, DuraLiner II). They concluded that disinfection by immersig in sodium perborate or microwave waves increases the surface roughness and hardness of the tested materials (Machado et al., 2009). ZHANG et al (2009) investigated the effects of nano-ZrO2 and Whisker aluminum borate on the flexural strength and hardness of the resin denture base surface of Poly methyl methacrylate. The flexural strength and surface hardness were evaluated using a three-point flexural test and Whickers hardness test. The results showed that the mechanical behavior of the ZrO2-ABW / PMMA composites improved significantly and the flexural strength and surface hardness increased significantly (Zhang et al., 2014). The present study also showed that the acrylic roughness resistance increased with adding TiO2. In a study conducted by Odagir et al, the effects of certain disinfectants on the stability of a Poly methyl methacrylate base denture, consisting of a new disinfection method using reactive oxygen species (ROS) to investigate the disinfectant effect on the material properties and roughness was analyzed. The following disinfectants were tested: 5%sodium hypochlorite, 70% alcohol, and ROS. The disinfection method increased sodium hypochlorite and surface roughness and decreased the flexural strength.

These results indicate that using 5% hypochlorite solution increases the surface roughness of the resin denture base than the control group (Odagiri et al., 2012) . The present study also showed that disinfection of acrylic sodium hypochlorite increases its roughness. In a study by Badaro et al. In 2017, which investigated the effect of immersion of acrylic resin in Ricinus communis and sodium hypochlorite, it was concluded that immersion of acrylic resin in 0.5% sodium hypochlorite increased the amount of acrylic resin roughness (Badaró et al., 2017) which is consistent with the results of this study.These results indicate that using 5% hypochlorite solution increases the surface roughness of the resin denture base compared to the control group (Odagiri et al., 2012). The present study also showed that acrylic disinfection with sodium hypochlorite increased its roughness. In a study conducted by Badaro et al in 2017to examine the effect of immersion of acrylic resin in Ricinus communis and sodium hypochlorite, it was concluded that immersion of acrylic resin in 0.5% sodium hypochlorite increased the acrylic resin roughness (Badaró et al., 2017), which is consistent with the results of this study.

In another study conducted by Schepanski et al under the title of the effect of 1% sodium hypochlorite and 1% peracetic acid on the roughness of surfaces of hot water- polymerized acrylic resins over a long and short period of time, 40 acrylic resin samples were divided into four groups according to polymerization time and antiinfectant. The samples were immersed in a 1% NaClO solution or 1% C2H4O3 for 30 minutes. The results showed that there is a significant difference between the short and long periods of time cycles in terms of roughness and the roughness increased in longer periods of time (Sczepanski et al., 2014). The results of the data analysis in this study also showed that increasing time leads to increased acrylic roughness. In a study conducted by Li study in 2014 to examine the frictional and wear properties of SiO2 and TiO2 nanocomposites, results showed that adding TiO2 enhanced the resistance to increased roughness (Li, 2014).

In the present study, the results showed that TiO2-reinforcd acrylic had higher resistance to roughness than conventional heat-cured acrylic. Aziz (2018) also examined the effects of Tio2 nanoparticles on some of the characteristics of high impact acrylic resins using various processing techniques. A total of 120 high impact acrylic resins were divided into 2 groups based on cure (microwave, water bath) methods and each group divided into two subgroups of control (without Tio2) and Tio2 nanoparticles group. The results showed that reinforcing the acrylic resin with 3% Tio2 caused significant increase in impact strength of acrylic resin (Aziz, 2018). This study showed that the presence of Tio2 as reinforcing phase in resin improved some of the acrylic resin properties. In addition, scanning electron microscopy images showed that the effect of Tio2 is good when its nanoparticles are disributed uniformly in acrylic resin.

Conclusion

By adding 1% Tio2 powder to heat-cured acrylic, the denture resistance to increased surface roughness increased, compared to two solutions of sodium hypochlorite and NatureDent tablet. Moreover, with increasing time, the effect of type of disinfectant solution on the roughness increases, which this effect is lower in Tio2- reinfirced acrylic resin that in conventional acrylic resin.

References

Aziz HK. TiO2-Nanofillers Effects on Some Properties of Highly- Impact Resin Using Different Processing Techniques. Open Dent J 2018;12:202-212.

Badaró MM, Salles MM, de Arruda CNF, Oliveira VdC, de Souza RF, Paranhos HFO, et al. In vitro analysis of surface roughness of acrylic resin exposed to the combined hygiene method of brushing and immersion in Ricinus communis and sodium hypochlorite. Journal of Prosthodontics 2017;26(6):516-21.

Berger JC, Driscoll CF, Romberg E, Luo Q, Thompson G. Surface roughness of denture base acrylic resins after processing and after polishing. J Prosthodont 2006;15180-186.

da Silva FC, Kimpara ET, Mancini MN, Balducci I, Jorge AO, Koga-Ito CY. Effectiveness of six different disinfectants on removing five microbial species and effects on the topographic characteristics of acrylic resin. J Prosthodont 2008;17:627-633.

Ebadian B,Poorsina F,Saghaei S. Evaluation of disinfecting effect of 0.5%sodium hypochlorite and 2% glutaraldehyde on heat cure acrylic resin. J Mashhad Dent Sci 2007;31(3):217-22.

Felipucci DN, Davi LR, Paranhos HF, Bezzon OL, Silva RF, Pagnano VO. Effect of Different Cleansers on the Surface of Removable Partial Denture. Braz Dent J2011;22(5):392-7.

Fernandes FH, Orsi IA, Villabona CA. Effects of the peracetic acid and sodium hypochlorite on the colour stability and surface roughness of the denture base acrylic resins polymerised by microwave and water bath methods. Gerodontology. 2013 Mar;30(1):18-25.

International Standards Organization ISO 1567:1999/Amd 1:2003.Dentistry - Denture base polymers.

Kado D, Sakurai K, Sugiyama T, Ueda T. Evaluation of cleanability of a titanium dioxide (TiO2)-coated acrylic resin denture base. Prosthodontic Research & Practice 2005;4(1):69-76.

Kulak-Ozkan Y, Kazazoglu E, Arikan A. Oral hygiene habits, denture cleanliness, presence of yeasts and stomatitis in elderly people. Journal of oral rehabilitation 2002;29(3):300-4.

Li Z. The friction and wear properties of nano-SiO2 and-TiO2 particle-reinforced PMMA composites. Journal of Thermoplastic Composite Materials 2014;27(6):793-800.

Machado AL, Breeding LC, Vergani CE, da Cruz Perez LE. Hardness and surface roughness of reline and denture base acrylic resins after repeated disinfection procedures. J Prosthet Dent2009 ;102(2):115-22.

Nematollahi, F., et al., Evaluating the Effect of Four Chemical Disinfectants on Surface Roughness of Acrylic Resin Denture Base Material (in vitro evaluation). Res Dent Sci 2014;11(3): 160-166.

Odagiri K, Sawada T, Hori N, Seimiya K, Otsuji T, Hamada N, et al. Evaluation of denture base resin after disinfection method using reactive oxygen species (ROS). Dental materials journal 2012;31(3):443-8.

Paranhos H, SILVA-LOVATO C, Souza R, Cruz P, Freitas K, Peracini A. Effects of mechanical and chemical methods on denture biofilm accumulation. Journal of oral rehabilitation 2007;34(8):606-12.

Paranhos Hde F, Davi LR, Peracini A, Soares RB, Lovato CH, Souza RF.Comparison of physical and mechanical properties of microwave-polymerized acrylic resin after disinfection in sodium hypochlorite solutions. Braz Dent J2009;20(4):331-5.

Phoenix RD, Cagna DR, DeFreest CF, Stewart KL. Stewart's Clinical Removable Partial Prosthodontics. 4th Edition. Chicago : Quintessence ;2008.

Pinto LR, Rubim D, Silva PMB, Porto VC. Effects of repeated long-term sodium hypochlorite disinfection treatment on surface hardness and roughness of self-polymerizing reline acrylic resins. Journal of Research in Dentistry 2014; 2(1):91-101.

Pisani MX, Macedo AP, Paranhos Hde F, Silva CH. Effect of experimental Ricinus communis solution for denture cleaning on the properties of acrylic resin teeth. Braz Dent J2012; 23(1):15-21.

Porwal A, Khandelwal M, Punia V, Sharma V.Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. J Indian Prosthodont Soc 2017; 17(1):61-67.

Sczepanski F, Sczepanski CRB, Berger SB, Consani RLX, Gonini-Junior A, Guiraldo RD. Effect of sodium hypochlorite and peracetic acid on the surface roughness of acrylic resin polymerized by heated water for short and long cycles. European journal of dentistry 2014; 8(4):533.

Sharma P, Garg S, Kalra NM. Effect of Denture Cleansers on Surface Roughness and Flexural Strength of Heat Cure Denture Base Resin-An In vitro Study. J Clin Diagn Res 2017; 11(8): ZC94-ZC97.

Shay K. Denture hygiene: a review and update. The J Contemp Dent Pract 2000; 1(2):28-41.

Shen C, Javid NS, Colaizzi FA. The effect of glutaraldehyde base disinfectants on denture base resins. J Prosthet Dent 1989; 61(5):583-9.

Shirkavand S, Moslehifard E. Effect of TiO2 nanoparticles on tensile strength of dental acrylic resins. Journal of dental research, dental clinics, dental prospects 2014; 8(4):197.

Zhang X-Y, Zhang X-J, Huang Z-L, Bang-Shang Z, Rong-Rong C. Hybrid effects of zirconia nanoparticles with aluminum borate whiskers on mechanical properties of denture base resin PMMA. Dental materials journal 2014; 33(1): 141-6.