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Original Article

The Effects of Nanosil D2 Disinfectant on the Surface Roughness of Denture Base Acrylic Resin

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Abstract

Background: The chemical disinfectants used for reducing the plaque accumulation should have the least side-effects on the surface of the denture base. This study investigates the impact of Nanosil D2 solution on the surface roughness of acrylic denture base in the laboratory.

Methods: This experiment was conducted on 44 Acropars acrylic resin samples that were divided equally into the experimental (n=22) and control (n=22) groups through random selection. The surface roughness of all samples was measured by using the PS1 profilometer according to Ra and Rz. Then, for eight hours, the control samples were put in the water and the experimental samples were put in Nanosil disinfectant solution, and then the samples were extracted and put in distilled water for 16 hours. The disinfectant solution was changed once in a day and this process continued for 180 days. After 180 days, the surface roughness of the samples was measured once again. The data was evaluated through SPSS software 17.

Results: There was no significant difference in the mean Ra between pre-test and post-test values in each group ($P>0.05$); however, after immersion in the solutions, the mean Ra was significantly more in Nanosil group ($P<0.05$). There was a significant difference between the mean Rz in Nanosil group before and after immersion in the solution, ($P<0.05$); however, there was not any difference in the control group ($P>0.05$).

Conclusion: The use of Nanosil D2 solution for disinfecting the acrylic denture base in 180 days and 8 hours per day simulating four years, does not cause significant changes in its surface roughness.

Keywords: Denture cleansers, Nanosil D2, Surface roughness

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Introduction

We are all in direct contact with microorganisms and microbes which are known to be normal flora (1,2). In the oral cavity, the presence of abundant food, dead epithelial cells, and the salivation process will create a good environment for bacterial growth (3,4). Naturally, this microbial flora will affect the denture as it affects oral and dental health (5). In fact, the prosthesis acts as a plaque carrier just like the natural teeth, and these plaques will damage the soft tissue, oral mucosa, bone degeneration, and eventually damage the overall health status of the individual. Besides, plaque will result in unpleasant mouth smell and ugly face.

The presentation of acrylic resins was a great evolution in the dentistry. Acrylic resins are mostly known as poly (methyl methacrylate) (PMMA) (6). Heat-activated PMMA, besides its advantages has disadvantages such as high porosity, high water absorption, High volume change, and the presence of residual monomers. On the other hand, denture cleaning is necessary for oral and prosthesis health. Therefore, it is very important to choose a suitable cleaner that, while efficient and durable, retains the properties of the denture base resin (7).

Denture cleaners affect the denture plaques in mechanical and chemical ways. Although the chemical cleaners such as alkaline hydrochlorides, alkaline peroxides, diluted acids, disinfectants, and enzymes are more effective in removing the plaques than the mechanical one (8), routine use of these cleaners result in physical and mechanical changes of acrylic resins, such as changes in color, bending strength, and surface roughness (9,10). The increase in surface roughness will gradually lead to microbial adhesion and food particles to the acrylic surface that can lead to irritation and

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inflammation of the oral mucosa (11).

Various studies have been performed on the effect of disinfectants on surface changes and surface roughness in acrylic resins. Considering the variations in materials, acrylic resins, and the duration of immersion, it seems that some points need to be considered. Some in vivo studies have recommended a threshold of 0.2 mm for surface roughness, i.e. an increase from this threshold will result in spontaneous accumulation of microbial plaque (12,13). Garcia et al have investigated the effect of one denture cleaner (Polident) on the surface roughness, tensile strength, and acrylic resins' weight. The impact of Polident and water solutions on resins' surface roughness and tensile strength was the same (14). While, Machado et al found that the use of chemical solutions including Chlorhexidine, peracetic acid, sodium hypochlorite, alkaline peroxide tablets increases the surface roughness of acrylic resins (15).

Nanosil disinfectant is a combination of hydrogen peroxide and a minor proportion of silver ions. Due to its silver ion content, it is a strong long-acting antiseptic. Besides, due to anti-bacterial properties and the release of oxygen from hydrogen peroxide, it prevents the proliferation of non-aerobic microbial populations effective in periodontal disease. Kimiafam Pharmaceutical Company has claimed that the Nanosil D2 solution is an ideal disinfectant which is highly recommended for disinfecting both surfaces and equipments (16,17).

Due to the lack of research on the impacts of Nanosil D2 solution on the surface roughness of denture base acrylic resins and also the prevalence of using chemical materials for cleaning dentures among the patients, this study aimed at investigating the effects of Nanosil D2 solution on the surface roughness of Acropars' acrylic resins. The results of this study are expected to be effective in reducing the surface roughness changes of acrylic denture bases. Thus, all patients using dentures will benefit from this study.

Methods

In this laboratory, case-control study, 22 samples were included in each group and a total of 44 acrylic samples were made using a metal mold with a 17 mm diameter and 6 mm height.

To make the acrylic samples (Acropars, Marlic Medical Co, Tehran, Iran), white plaster (Pars dental Co, Tehran, Iran) was used in the lower part of flask and a glass slab put on it. After the plaster hardened, and using biofilm on the plaster, the metal molds were glued to the surface of the glass.

Then, the metal molds were filled by melting wax (Modeling wax, Dentsply GmbH, England) and the surface has been leveled. Then, another glass slab has been placed on the molds and the stone plaster (Type III Moldston, Pars dental Co, Tehran, Iran) was poured onto the upper half of the flask; such that the plaster covered the circumference of the metal molds. After the second layer of plaster hardened with the glass slab in its place, the third plaster was poured and flask lid closed and pressured until the plaster hardened. Then, the flasks were put in hot water for 4 to 6 minutes until the wax melts. Then, acrylic material (Acropars, Marlic Medical Co., 100, Iran) was prepared according to the manufacturer's instructions with respect to powder-liquid ratio, mixing, and packing. A standardized polymerization procedure was followed; with one cycle at 70°C for 8 hours followed by a 1 hour cycle at 100 °C under flask clamp pressure. The flasks were then left to cool at room temperature. By performing this type of waxing, relatively fine acrylic specimens were prepared.

The samples were brought out from the molds and immersed in distilled water with temperature of 37 ± 1°C for 50 ± 2 hours to remove the residual monomers. To polish the samples' surface, silicon carbide sandpapers (600 grit) were used. In the next stage, the surface of the disc-shaped specimens was finished using a fluffy wheel and a felt cone with pumice. Using a one-row brush wheel and a fluffy wheel with a quarter of one inch wide and pumice, the acrylic surfaces were polished. In order to unify the results, the polishing process was made by one person from the beginning to the end and under mild pressure. The polish duration was the same for all the samples and it was measured carefully using a chronometer (18,19).

Therefore, 44 acrylic samples were made which divided into two experimental (n = 22) and control (n = 22) groups based on random selection.

Then, the surface roughness of the samples was evaluated based on average roughness (Ra) and Rz by the PS1 profilometer device (MAHR, pocket model, Germany).

The control group samples were immersed in urban water (v = 100 mL) and the experimental samples were immersed in Nanosil D2 disinfectant solution (v = 100 mL) (Kimiafam Company, Iran) for eight hours (Simulation cleansing during the night). Then, the samples were extracted and immersed in distilled water for 16 hours. The disinfectant was renewed every day and this routine repeated for 180 days (18).

The data were analyzed using descriptive statistics methods (mean and standard deviation) as well as independent t-test and through SPSS 17. The normal distribution of the data was evaluated using the Kolmogorov-Smirnov test and Q-Q graph. The significance level was $P < 0.05$.

In order to compare the surface roughness of the two groups in both pre-test and post-test, analysis of covariance (ANCOVA) was used. Besides, to compare the same amount for both groups separately, just the paired *t* test was used because the data were in a normal distribution.

Results

There was no statistically significant difference in the Ra mean between the two evaluation times in each of case and control groups ($P > 0.05$). Also, there was no statistically significant difference in the Ra mean between the two groups before placing in the solution ($P > 0.05$). But, after placing in the solution, there was a significant statistical difference in Ra mean between the two groups and this value was more in the experimental group (Figure 1).

Further analysis about the Rz mean revealed that there was no statistically significant difference in Rz mean between the two groups in the pretest ($P > 0.05$) and it was not significantly different in both groups in the post-test as well ($P > 0.05$).

But, in the case group, there was statistically significant difference in Rz means of pre-test and post-test so that it was more in post-test ($P < 0.05$). In the control group, there was not any significant difference in Rz means of pre and post-tests ($P > 0.05$; Figure 2).

Discussion

Acrylic prostheses can be cleaned with disinfectant solutions at home. However, these disinfectants change the properties of polymeric materials (20). A variety of active agents such as sodium hypochlorite, glutaraldehyde and vinegar have been used for the chemical disinfection of the denture base which have negative effects on the properties of acrylic resin. Since the surface roughness is an important property due to its influence on microbial adhesion (21), in the present study, Nanosil D2, as a chemical disinfectant, has been used to investigate its impact on surface roughness (Ra and Rz) of one heat-cured resin.

Different methods are used for roughness measurement. In North America, the most common parameter for surface texture is Ra. Ra is calculated by an algorithm that measures the average length between the peaks and valleys and the deviation from the mean line on the entire surface within the sampling length. It is a simple and effective method for monitoring surface texture and ensuring consistency in the measurement of multiple surfaces.

In Europe, the more common parameter for roughness

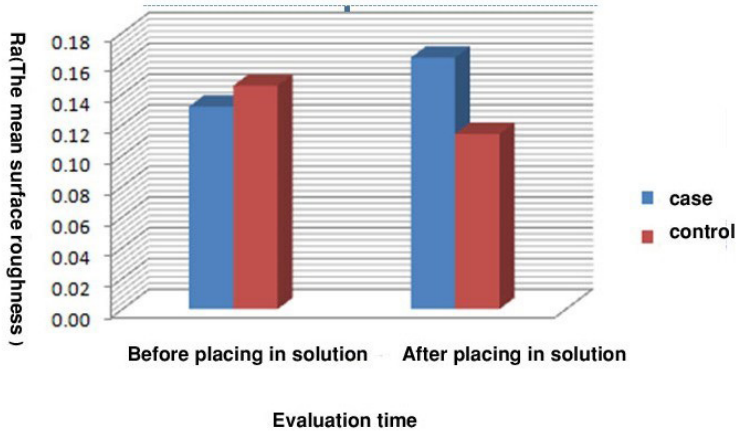

Figure 1. Average Ra (the mean surface roughness) in two times in the two groups

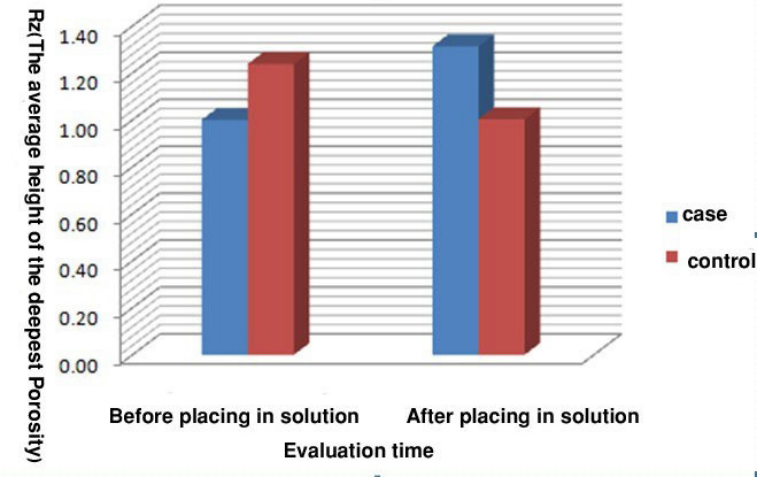

Figure 2. Average Rz (the mean height of the deepest porosity) in two times in the two groups

is mean roughness depth (Rz). Rz is calculated by measuring the vertical distance from the highest peak to the lowest valley within five sampling lengths, then averaging these distances (22).

After immersion in Nanosil D2, Ra was not different from baseline (pretest) but different from urban water, used as the control. Ra mean in urban water has decreased, which may be due to the effects of its salts and minerals on acrylic resin. For this reason, after placing in the solution, there was a significant statistical difference in Ra mean between the two groups and this value was more in the experimental group. But, after immersion in Nanosil D2, Rz mean increased.

The cumulative effect of disinfectants over time can adversely affect the mechanical and surface properties of acrylic resin; therefore, in this study, the immersion of the acrylic resin samples for 180 days and 8 hours per day simulates one hour a day in contact with disinfectant for a period of four years.

Clinically acceptable roughness of hard surfaces in the oral environment after polishing should not exceed 0.2 µm (threshold value) (23).

The ISO standard is used for categorizing various finish surfaces, which includes 12 stages for Ra and Rz as Table 1.

Considering Figures 1 and 2, it can be said that the means Ra and Rz of the samples were not higher than 0.16 and 1.30 respectively under any circumstances, and concerning the table above, we can argue that it is in the acceptable range and therefore the use of Nanosil D2 disinfectant solution for disinfecting the acrylic in four years does not cause significant changes in acrylic roughness.

Köroğlu et al studied the effect of teeth disinfectant solutions on reducing the surface roughness of the prosthesis-based resins containing sealant. Sodium hypochlorite %5 (NaOCl) and Sodium perborate (Rapident, Corega) were in direct contact with the samples for 90 days. There was a significant difference in surface roughness values before and after 90 days of immersion (24).

Porwal et al investigated the impact of disinfectant materials on three different denture materials for 180 days. The highest change in surface roughness was for the conventional heat-cured resin immersed in sodium hypochlorite (12).

Ebadian et al studied the impact of sodium hypochlorite and Glutaraldehyde on two types of acrylics, namely Acropars and Meliodent. They found that sodium hypochlorite has caused further changes compared with Glutaraldehyde (11). This was consistent with de Freitas Oliveira Paranhos and colleagues' study of the effect of three types of disinfectants on surface roughness and the hardness of three types of acrylic (25).

Pavarina et al showed that denture immersion in chlorhexidine and 25.5% sodium hypochlorite will increase acrylic denture's surface roughness (26). On the other hand, de Freitas Oliveira Paranhos and colleagues in one study (27) and Azevedo et al (28) in another study, used %1 sodium hypochlorite solution and found that similar to our study it has no adverse effects on acrylic surface roughness.

Sharma et al studied the effect of various chemical disinfectants on surface roughness and bending strength of conventional heat-cured resin for three months and found that unlike our study, surface roughness of the samples increased significantly after three months of immersion in 1% sodium hypochlorite solution and bending strength reduced ($P<0.05$); however, no statistically significant change was observed in bending strength and surface roughness of samples immersed in Fitty dent and vinegar for three months (7).

These different and sometimes contradictory results regarding Ra and Rz values can be interpreted from the perspective that disinfectants at higher concentrations can have an emollient effect on acrylic matrix and also dissolve free monomers and subsequently decompose the matrix. Therefore, different results in different studies can be related to different concentrations of disinfectant solutions (12).

It should be noted that in all of the above studies, using different disinfectants, Ra and Rz are higher than the corresponding values in our study and therefore it can be said that Nanosil produces less roughness than other materials such as glutaraldehyde and sodium hypochlorite.

Conclusion

Due to the limitations of this study, the use of Nanosil D2 solution for disinfecting the acrylic denture base in four years does not cause significant changes in its surface roughness.

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Table 1. Roughness grades for the mean Ra and Rz according to ISO standard

Roughness Grade	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
Ra in µm	0.25	0.05	0.1	0.2	0.4	0.8	1.6	3.2	6.3	12.5	25	50
Rz in µm	0.25 0.4	0.4 0.63	1	1.6	2.5	4 6.3	10	16 25	40	63	100	160

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Project administration: Tahereh Ghaffari.
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Supervision: Tahereh Ghaffari.
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Conflict of interests
There is no conflict of interest to declare.

Ethical Approval
The study was approved by the ethics committee of Tabriz Medical University (Ethic code: IR.Tbzmed.VCR.REC.1398.100).

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