The Effect of a Commercial Denture Cleansing Solution and Four Household Agents on Surface Roughness of Heat-Cured Acrylic Resin

Sita Thaworanunta[*1], Naluemol Sriprasert[2], Chutimon Nanarong[3], Pichsinee Dittaratchaphong[3], Thananya Momin[3], and Thanpitcha Krisanawong[3]

[1]Assistance Professor, Prosthodontics Dep, College of Dental Medicine, Rangsit University, Pathumthani, Thailand.
[2]Lecturer, Prosthodontics Dep, College of Dental Medicine, Rangsit University, Pathumthani, Thailand.
[3]Undergraduate Students in College of Dental Medicine, Rangsit University, Pathumthani, Thailand.
[*]Corresponding author, E-mail: sita.th@rsu.ac.th

Abstract

This study aims to evaluate the surface roughness of heat-cured acrylic resin after immersion in 4 different solutions of household agents and a commercial denture cleansing solution. Seventy-two 10x10x2 mm^3 disc-shaped specimens were fabricated from heat-cured acrylic resin and divided into 6 groups. Twelve specimens in each group were immersed in 4 household agents (100% clear vinegar, 5% acetic acid, and 0.1% and 0.5% Sodium hypochlorite), while a commercial denture cleansing solutions: Polident® (Block Drug Company Inc, Memphis, TN38113, USA.) and tap water served as a negative control. All specimens were immersed 10 minutes/time, 5 times/day for 36 days representing 6 months of clinical service. The surface roughness (Ra, µm) was measured before and after immersion with a non-contact surface roughness tester (Infinite Focus SL, Alicona®, Austria). All data were compared by One-Way ANOVA and Tukey test, with a significance level of 0.05. The mean difference of surface roughness of the control group and test group; Polident®, 100% clear vinegar, and 5% acetic acid, was not significantly different ($P > 0.05$) but 0.1% and 0.5% sodium hypochlorite showed a significant difference ($P < 0.05$) in higher surface roughness. The surface roughness of heat-cured acrylic resin immersed in 0.1% and 0.5% sodium hypochlorite was significantly different from the other groups. 100% clear vinegar and 5% acetic acid were not significantly different from Polident®, which is the representative of commercial denture cleansing solutions. Therefore, 100% clear vinegar and 5% acetic acid that are household agents can be the alternative options for the routine used.

Keywords: *Acetic acid, clear vinegar, Commercial denture cleansing solutions, Denture cleansing solution, Sodium hypochlorite, Surface roughness, Heat-cured acrylic resin*

1. Introduction

Thailand is entering into an aging society according to the National Statistical Office of Thailand showed that in 2019 the aging population of Thailand's 66 million is 16.73%. Thai National Oral Health Survey by the Department of Health, Ministry of Public Health (2018) also showed that 1 million elderly people needed to wear complete dentures, and 4.9 million people needed to wear removable partial dentures. Axe, Varghese, Bosma, Kitson, and Bradshaw (2016) stated that denture wearers often suffer from the anxiety of further oral care problems such as the esthetic problems of the denture, malodor, and staining. From this information, cleaning dentures properly is very important in eliminating plaque and maintaining good oral hygiene for denture wearers.

Heat-cure acrylic resins are the most commonly used for denture base materials (Kotha Sujitha, Lakshminarayana, Shareef, Lavanya, & SivKumar, 2018). The properties of denture base are required biocompatibility, dimensional stability, flexural strength, and surface roughness. The surface roughness of the denture base is clinically important in the process of containing plague and bacteria (Bollen, Lambrechts & Quirynen, 1997). Candida albicans is the most common opportunistic pathogen found in the oral cavity, which can cause oral diseases such as denture stomatitis. The adherence mechanisms of Candida albicans to the denture base are significantly affected by surface roughness and other microorganisms in the oral cavity (Al-Fouzan, Al-mejrad & Albarrag, 2017).

The acceptable clinical final surface roughness after polishing should be lower than the critical threshold of 0.2 micrometers, to prevent plaque accumulation (Babina et al., 2020).

There are two major approaches to clean the denture base. The first is mechanical methods such as brushing and ultrasonic cleanser. They are the most commonly used and effective procedure for reducing and removing biofilm formation (Shay, 2000; Paranhos et al., 2014). However, brushing may be influenced by the manual skills of the denture wearers.

The second is chemical cleaning methods that immersed the denture base in different chemical agents such as alkaline peroxides, alkaline hypochlorite, acids, and disinfectants (Gautham et al., 2016; Shay, 2000; Paranhos et al., 2014). These methods may be an excellent complement to mechanical methods, since they reduce the number of microorganisms adhering to dentures, compensate possible limitations of brushing, have good acceptance by wearers, and are easy to use (Jagger & Harrison, 1995; Nishi et al., 2012).

One of the chemical methods is an immersion in commercial denture cleansing solutions. A good denture cleansing solution should not alter denture properties, such as color change, dimensional stability, strength, and especially surface roughness (Sharma, Garg & Kalra, 2017). In geriatric or handicapped patients who are denture wearers, as their manual dexterity may be compromised, chemical denture cleansers can be a better alternative (Barochia & Kamath, 2018).

There are difficulties to find commercial denture cleansing solutions in rural areas. If the household agents such as sodium hypochlorite, and clear vinegar could be used to clean the denture and do not affect the surface roughness noticeably microscopically, denture wearers would have an appropriate choice to clean their dentures.

2. Objective

To compare the surface roughness of heat-cured acrylic resin after immersion in 4 different solutions of household agents and a commercial denture cleansing solution

3. Materials and Methods

The heat-cured acrylic resin (Vertex TM, Dental B.V. Asia Pte Ltd, The Netherlands), the commercially available denture cleansing solution: Polident® (Block Drug Company Inc, Memphis, TN38113, USA) and four household agents such as 0.1% and 0.5% sodium hypochlorite (Suksapan®, Thailand), 100% clear vinegar (อสร®, PFO FOOD co.,ltd, Thailand) and 5% acetic acid (Suksapan®, Thailand) were used in this study. This study was performed based on the following calculation: the immersion in each solution 10 minutes/cycle repeated 5 cycles a day for 36 days, which is equivalent to 6-month of clinical services.

Surface roughness was measured by a non-contact surface roughness tester (InfiniteFocus SL, Alicona®, Austria) and for each specimen, the setting was at a speed of 0.5 mm/s. The alteration in surface roughness was obtained by the difference between pre-immersion and post-immersion.

3.1 Specimens preparation

Seventy-two 10x10x2 mm^3 disc-shaped specimens were fabricated from the heat-cured acrylic resin by using stainless steel mold. The mold used for the preparation of the test specimens was applied by separating the medium. The heat-cured acrylic resin was used in the powder-liquid form. The powder and liquid were mixed in ratio as recommended by the manufacturer. When the mix reached the dough stage, it was packed into mold space and processed according to the manufacturer's instructions. A long cure cycle of polymerization (73°C for 90 minutes, followed by 94°C for 30 minutes) was done. The specimens were removed from the molds and finished with 1000 and 2000 grit sandpaper respectively and followed by a buffing polishing wheel. The other surfaces were marked with a number and left unpolished to distinguish the experimental surface that will be measured with a surface roughness tester. After that, all specimens were steamed in ultrasonic cleaning.

3.2 Immersion procedures

All specimens were divided into 6 groups. Before immersion, the surface roughness of all groups was measured through a non-contact surface roughness tester. The results showed that all groups were not

significantly different at T0, confirming that all specimens had the same surface roughness. 12 specimens in each group were immersed in 4 household agents: 100% clear vinegar (Suksapan®, Thailand), 5% acetic acid (Suksapan®, Thailand), and 0.1% and 0.5% Sodium hypochlorite (Suksapan®, Thailand), whereas the commercial denture cleansing solutions: Polident® (Block Drug Company Inc, Memphis, TN38113, USA.) and tap water served as a negative control.

After immersion in the respective solutions for 10 minutes, each test specimen was rinsed in running tap water for 2 minutes and were immersed in a new respective solution. The procedure for each solution was repeated 5 cycles a day for 36 days, which is equivalent to 6-month of clinical service. During non-immersion time, all specimens were stored in tap water.

Table1: Percent, brand, time of denture cleansing solution and four household agents

Solutions	Conc.	Brands	Time (mins.)
Tap water as a negative control	-	-	10
Denture cleansing solution	-	Polident®, Block Drug Company. Inc, USA.	10
Clear vinegar	100%	Suksapan®,Thailand	10
Sodium hypochlorite (NaOCl)	0.1%	Suksapan®,Thailand	10
Sodium hypochlorite (NaOCl)	0.5%	Suksapan®,Thailand	10
Acetic acid	5%	Suksapan®,Thailand	10

3.3 Data analysis

The data analysis was performed using one-way analysis of variance (ANOVA) and Post-hoc Tukey test to compare and evaluate interactions between different groups. All statistical analyses were set at a significance level of < 0.05. The statistical tests were calculated using the SPSS 20.0 program (SPSS Inc., Chicago, IL, USA)

4. Results and Discussion

The descriptive analysis was used to show information including mean and standard deviation of Ra (T6 – T0) roughness as presented in Table 2.

The results of one-way ANOVA in Table 3 analyze that the null hypothesis is rejected ($\alpha=0$), the mean difference of ΔRa for all cleansing solutions has at least one pair that show statistical significance. Therefore, to find the ΔRa mean difference of all cleansing solutions, there must be multiple comparisons by using the Tukey test for Post-Hoc analysis test as in Table 4.

Table 2: The ΔRa roughness of the heat-cured acrylic resin due to the interaction between period and immersion solutions

Cleansing solutions	N	Mean	Standard Deviation
Tap water	12	0.2194	3.1943
Polident®	12	2.7164	3.2575
Clear vinegar	12	-0.9084	5.7410
5% Acetic acid	12	2.6159	3.7155
0.1% NaOCl	12	20.6024	5.0344
0.5% NaOCl	12	24.0767	4.7103

From Table 2, the mean of ΔRa has the lowest and highest values -0.9084 and 24.0767, respectively. The next test will be the mean difference of ΔRa for all cleansing solutions by using one-way ANOVA as presented in Table 3.

Table 3: The result of one-way analysis of variance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7365.496	5	1473.099	76.783	.000
Within Groups	1266.224	66	19.185		
Total	8631.720	71			

Table 4: The result of Tukey's test for Post-Hoc analysis

GROUP	N	Subset for alpha = 0.05	
		1	2
Tap water	12	.2194	-
Clear vinegar	12	-.9084	-
Polident®	12	2.7164	-
5% Acetic acid	12	2.6159	-
0.1% NaOCl	12	-	20.6024
0.5% NaOCl	12	-	24.0767
Sig.		.339	.386

Cleansing dentures is an important procedure; not only to reduce the risk of oral infection but also to improve the denture's longevities. There are two methods to clean acrylic dentures including mechanical methods, such as brushing, and chemical methods, such as using a denture cleansing solution. Recent studies show that most mechanical methods increase surface roughness that causes more plaque retention. Thus, the chemical method is still the first choice to clean dentures in terms of reducing biofilm formation due to the less abrasive surface roughness.

Denture cleansing solution is a better method recommended especially for handicaps and geriatric patients. A study by Ozyilmaz and Akin (2019) revealed that ideally, denture cleansers should reduce or remove the biofilm without altering the physical and mechanical properties of the denture base material. Nevertheless, many studies found that the daily use of denture cleansing solutions can affect the mechanical and chemical properties including the color, surface roughness, and hardness of denture base material.

Although many commercial denture cleansing solutions are available in the market, most of them are still not available in rural areas and expensive. Therefore, the results of our study provide choices for people who cannot obtain and afford commercial denture cleansing solutions in terms of surface roughness.

In this study, 100% clear vinegar, 5% acetic acid, 0.1%, and 0.5% sodium hypochlorite were used as household agents. Besides, the authors used Polident® as a representative of the commercial cleaning dentures.

A solution of 100% clear vinegar appears to be a mild acid solution, sour taste, and unsatisfactory pungent odor but it is reported to have antibacterial and antifungal properties (Kumar, Thippeswamy, Raghavendra Swamy & Gujjari, 2012; Peampring et al., 2014). This study is similar to Sharma, Garg, and Kalra (2017) who found that the surface roughness of the denture base did not cause much change after immersing in the 100% vinegar and denture cleansing solution.

Acetic acid is one and the most important component of vinegar but clear vinegar also contains other by-products. In this experiment, the authors would like to confirm that other by-products from vinegar manufacturing methods do not affect the surface roughness of acrylic denture specimens. So, the authors titrated pure acetic acid into 5% related to the amount of acetic acid in clear vinegar and did the experimental as well. From Table 4, the results showed that surface roughnesses between clear vinegar and 5% acetic acid were not scientifically different.

From this study, the surface roughnesses of both clear vinegar and 5 % acetic acid were lower than the critical threshold of 0.2 micrometers. Therefore, clear vinegar can be an alternative option for denture cleansing because it is easily available.

Chau, Saunders, Pimsler, and Elfring (1995) suggested that using 0.5% sodium hypochlorite at a 10-minute immersion could eliminate microorganisms from both the superficial and inner surface of acrylic resin. Sousa Porta, Lucena-Ferreira, Silva, and Cury (2013) stated that it was effective in reducing microorganisms without significant changes in color or roughness of denture resin. However, sodium hypochlorite increased surface roughness significantly (Sharma, Garg & Kalra, 2017). In this study, both 0.1% and 0.5% sodium hypochlorite increased surface roughness significantly, similar to the study of Porwal, Khandelwal, Punia, and Sharma (2017). They evaluated the effect of different denture cleansers in three denture base resin materials on color stability, surface hardness, and surface roughness. The result showed a maximum change in surface roughness of a conventional heat-cure acrylic resin when immersed in 0.5% sodium hypochlorite for 180 days. Sodium hypochlorite can cause structural changes in the polymeric matrix of acrylic resins. Such an effect could result in softening of the surface and, as a consequence, roughness would be expected to increase (Paranhos et al., 2009).

Arruda et al. (2018) stated that 0.1% sodium hypochlorite is still effective on biofilm removal when used in participants with denture stomatitis. Therefore, 0.1% sodium hypochlorite would be a better choice for cleansing denture than 0.5% sodium hypochlorite because it has less toxicity and adequate biofilm removal.

In a real situation, the patients will soak dentures in the cleansing solution for 10 minutes then wash them out and store them in tap water overnight. This study stimulated that situation by using running tap water for 2 minutes before immersion to a new solution in each cycle to eliminate the remaining cleansing solution. These processes represented soaking denture overnight with tap water.

5. Conclusion

From this study, the authors found that immersion in 0.1% and 0.5% sodium hypochlorite increased the surface roughness significantly. The other household groups were not significantly different from Polident® and tap water. However, this study was tested for 6 months and used only some household agents. A further study would be investigated in long-term use and include other household agents. Based on this

surface roughness data, 100% clear vinegar and 5% acetic acid can be the alternative denture cleansing solutions for geriatric or handicapped patients in rural areas for short-term routine use.

6. Acknowledgement

The authors gratefully acknowledge the financial support of the Research Institute of Rangsit University.

7. References

Al-Fouzan, A. F., Al-Mejrad, L. A., & Albarrag, A. M. (2017). Adherence of Candida to complete denture surfaces in vitro: A comparison of conventional and CAD/CAM complete dentures. *The Journal of Advanced Prosthodontics*, *9*(5), 402-408.

Arruda, C. N. F., Salles, M. M., Badaró, M. M., Sorgini, D. B., Oliveira, V. C., Macedo, A. P., Silva-Lovato, C. H., & Paranhos, H. F. O. (2018). Evaluation of biofilm removal and adverse effects on acrylic resin by diluted concentrations of sodium hypochlorite and Ricinus communis solutions. *Gerodontology*, *35*(3), 246-253. doi: 10.1111/ger.12348

Axe, A. S., Varghese, R., Bosma, ML., Kitson, N., & Bradshaw, D. J. (2016). Dental health professional recommendation and consumer habits in denture cleansing. *The Journal of Prosthetic Dentistry*, *115*(2), 183-188.

Babina, K., Polyakova, M., Sokhova, I., Doroshina, V., Arakelyan, M., & Novozhilova, N. (2020). The Effect of Finishing and Polishing Sequences on The Surface Roughness of Three Different Nanocomposites and Composite/Enamel and Composite/Cementum Interfaces. *Nanomaterials, 10*, 1339.

Barochia, J., & Kamath, S. (2018). Evaluation of the Effect of Denture Cleansers on the Surface roughness of hard denture base material: an in vitro study. *The Indian Journal of Dental Research*, *29*(5), 657-662.

Bollen, C. M., Lambrechts, P., & Quirynen, M. (1997). Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: A review of the literature. *Dental Materials*, *13*(4), 258-269.

Chau, V. B., Saunders, T. R., Pimsler, M., & Elfring, D. R. (1995). In-depth disinfection of acrylic resins. *The Journal of Prosthetic Dentistry*, *74*(3), 309-313.

Peampring, C., Chaiyanupong, N., Kositpantawong, N., Suwanrattapoom, P., Treeratweerapong, Y., & Prasert, L. (2014) In vitro stain removal capability of household vinegar as a denture cleaning solution. *Journal of the Dental Association of Thailand*, *64*(3), 172-179.

Department of health, Ministry of public health. (2018). The Thai national oral health survey in 2017 (pp. 68-69. สำนักทันตสาธารณสุข กรมอนามัย กระทรวงสาธารณสุข, บริษัทสามเจริญพาณิชย์ (กรุงเทพ) จำกัด

de Sousa Porta, S. R., de Lucena-Ferreira, S. C., da Silva, W. J., & Del Bel Cury, A. A. (2013). Evaluation of sodium hypochlorite as a denture cleanser: a clinical study. *Gerodontology*, *32*(4), 260–266.

Gautham, P., Mallikarjun, M., Chakravarthy, K., Kumar, K. R., Budege, V., & Bodankar, N. (2016). Assessment of denture hygiene maintenance among elderly patients in Nizamabad (Telangana) population: A survey. *Journal of Dr. NTR University of Health Sciences*, *5*(4), 275-280.

Jagger, D. C., & Harrison, A. (1995). Denture cleansing – the best approach. *British Dental Journal*, *178*(11), 413–417.

Kotha Sujitha, M. B., Lakshminarayana, S., Shareef, A., Lavanya, B., & SivKumar, V. (2018). Physical properties of heat cure denture base resin after incorporation of methacrylic acid. *Contemporary Clinical Dentistry*, *9*(Suppl 2), S251.

Kumar, M. N., Thippeswamy, HM., Raghavendra Swamy, KN., & Gujjari, A. K. (2012). Efficacy of commercial and household denture cleansers against candida albicans adherent to acrylic denture base resin: An in vitro study. *Indian Journal of Dental Research*, *23*(1), 39-42.

Nishi, Y., Seto, K., Kamashita, Y., Take, C., Kurono, A., & Nagaoka, E. (2012). Examination of denture-cleaning methods based on the quantity of microorganisms adhering to a denture. *Gerodontology, 29*(2), 259–266.

Ozyilmaz, O. Y., & Akin, C. (2019). Effect of cleansers on denture base resins' structural properties. *Journal of Applied Biomaterials & Functional Materials, 17*(1), 228080001982779.

Paranhos, H. D. F. O., Davi, L. R., Peracini, A., Soares, R. B., Lovato, C. H. D. S., & Souza, R. F. D. (2009). Comparison of physical and mechanical properties of microwave-polymerized acrylic resin after disinfection in sodium hypochlorite solutions. *Brazilian Dental Journal, 20*(4), 331-335.

Paranhos, H. D. F. O., Bezzon, O. L., Davi, L. R., Felipucci, D. N. B., Silva, C. H. L. D., & Pagnano, V. O. (2014). Effect of cleanser solutions on the color of acrylic resins associated with titanium and nickel-chromium alloys. *Brazilian Oral Research, 28*(1), 1-7.

Porwal, A., Khandelwal, M., Punia, V., & Sharma, V. (2017). Effect of denture cleansers on color stability, surface roughness, and hardness of different denture base resins. *The Journal of Indian Prosthodontic Society, 17*(1), 61-67.

Sharma, P., Garg, S., & Kalra, N. M. (2017). Effect of Denture Cleansers on Surface Roughness and Flexural Strength of Heat Cure Denture Base Resin-An In vitro Study. *Journal of clinical and diagnostic research, 11*(8), ZC94–ZC97.

Shay, K. (2000). Denture hygiene: a review and update. *The Journal of Contemporary Dental Practice, 1*(2), 28-41.

The Thai National statistical office. (2019). *Demography population and Housing statistics*. Retrieved December 25, 2020, from http://statbbi.nso.go.th/staticreport/page/sector/en/01.aspx