https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 27(3s) (October 2024); 6285 - 6291
Research Article

Effect of Denture Cleansers on Surface Roughness and Flexural Strength of High Impact Strength Acrylic Denture Base Materials: An *In Vitro* Study

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Abstract:
This study evaluated the effect of denture cleansers on surface roughness and flexural strength of high impact strength denture base material after successive immersions. A total of 50 specimens were fabricated and divided into 5 groups with 10 in each (n=10) based on the denture cleansing solution, Fittydent, Secure, Efferdent and Iodent. The specimens immersed in distilled water were considered as the control group. All the specimens were immersed in their respective cleansing solutions for 90 days. Surface roughness for all specimens before and after immersion was measured using surface profilometer and the flexural strength was measured after immersion for all specimens using universal testing machine. The collected data was analysed using one-way ANOVA with post hoc Tuckey test. All the specimens immersed in various denture cleansing solutions demonstrated more surface roughness compared to the specimens immersed in distilled water. A significant difference (p=0.0001) was observed among the groups after immersion for 90 days. The control group demonstrated more flexural strength compared to the specimens immersed in various disinfecting solutions for 90 days. However, no significant differences (p=0.9994) were observed in the flexural strength among the groups.

Keywords: Denture cleansers, Denture base resin, Flexural strength, Surface roughness.

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Received: 15/09/2024 *Accepted: 29/10/2024*

DOI: https://doi.org/10.53555/AJBR.v27i3S.3613

1. Introduction:

Over the past 80 years, polymethylmethacrylates (PMMA) have been the most commonly usedmaterials for the fabrication of denture bases. PMMA is popular because of its colour matching with the oral tissues, ease of handling, ease of construction and repair compared to other materials available for fabrication of dentures [1,2]. However, there are certain shortcomings with the use of PMMA which leads to denture fracture. Denture care is important for oral health especially in

elderly patients. Poor or unsatisfactory denture maintenance results in various side effects such as bad odour, unpleasant staining of denture, and biofilm formation on the denture surface which can lead to denture induced stomatitis, angular cheilitis and poor oral health [1-4].Denture cleaning is an important measure in which helps in prevention of growth of microorganisms, malodour and cross contamination and contributes to patient general health, denture longevity and overall quality of life [3-5].

The dentist should play a significant role in educating patient about denture cleaning and maintenance and educate the patient regarding the effects of improper maintenance of denture hygiene. Brushing alone is insufficient in controlling plaque on dentures. Various chemical denture cleansers can be used as adjunct for patients who are unable to properly care for their dentures [5]. Information provided by the American dental hygienists' association on care and cleaning of dentures identified the value of commercially prepared denture cleansers in form of powders, pastes, gels, creams, tablets, liquids [4,6,7]. Ideally, any disinfectant or denture cleanser should be beneficial without any harmful effects on the physical and mechanical properties of denture base when used for fabrication of denture base as a material of choice [3]. Denture cleansers may affect the key characteristics of polymethylmethacrylate (PMMA) including, hardness, surface roughness, color and flexural strength [3,6-8].

Irregularities and porosities present on the surface of acrylic denture base offer a favourable niche for retaining of stains and microbial plaque [7]. Fracture of acrylic denture base is a common problem and occurs during heavy masticatory loads which leads to base deformation and consequent resin fatigue [2,9-11]. Various studies demonstrated that immersion in disinfectants and denture cleansers may decrease the flexural strength,especiallyif warm water is used to prepare the cleansing solution [7,8].The composition and the immersion time are essential factors they influence the physical and mechanical properties of the dentures. The best denture cleanser should fulfil most of the requirements of ideal denture cleanser while not showing any kind of alternation in the structure of prostheses [8]. The present study was conducted to evaluate the effect of different commercially available denture cleansers on surface roughness and flexural strength of high impact strength denture base material at certain immersion periods.

2. Materials and methods

2.1 Sample preparation:

A total of 50 rectangular shaped (65mm X 10mm X 3.3mm) acrylic resin specimens according to the ISO 20795-1:2013 standardization [12] were fabricated with Lucitone 199 high impact strength acrylic denture base material (Dentsply Sirona, USA). After finishing and polishing of acrylic specimens, they were divided in to control group of 10 specimens and test group of 40 specimens. Test group specimens were further divided into 4 subgroups of 10 specimens each (n=10) depending on four different commercially available denture cleansing tablets.

2.2 Wax pattern preparation:

A glass slide of 3.3 mm thickness was cut into rectangular shape with the dimensions of 65mm length×10mm width×3.3mm thickness using adiamond cutter. The mix of Aquasil soft regular set putty (Dentsply, USA) was placed in a plastic box, the rectangular glass slide was placed over it to obtain a putty mould and covered with a glass slab. After the setting of the putty material, the glass slide was carefully retrieved.

Hard wax (Cavex set up, India) was made into pieces and melted in dental wax heater machine (Molten Labo 35, India). The molten was then poured into putty mould and covered with a glass slab. The wax pattern was retrieved after it has been set and the edges were shaped with Bp blade no 22. A total of 50 wax patterns were made using the same process.

2.3 Acrylic specimen fabrication:

Conventional flasking procedures using lost wax technique was carried out using plaster of Paris and dental stone to obtain the 50 specimens. Three wax specimens were invested in each flask. After completion of setting process, the dewaxing process was carried out by immersing the dental flasks were in boiling water for 4 minutes. After dewaxing, a layer of separating medium (Dental Products of India, India) was applied. Lucitone 199 heat-cure acrylic resin powder beads were mixed with monomer in the ratio of 3:1 by volume.The mix was packed into the investing mould after reaching to the dough stage, and spacer was placed over resin. The trail closure was performed under 2 lbs pressure to remove the excess flash and uniform distribution of acrylic dough throughout the mold cavity. Then, the mass was bench cured for 30 minutes. Then, the mass was transferred into a curing bath (Confident, India) and subjected to a fast curing cycle, which involved heating of the polymer dough at 74◦C for 1 ½ hours, followed by terminal boiling for 1 hour. After completion of polymerisation cycle, the flasks were allowed to cool slowly to room temperature in water bath. Dental flask removed from water bath and bench cooled for 30 minutes. Subsequently, theacrylic specimens were retrieved from flasks, excess was trimmed followed by finishing and polishing using metal burs, sandpapers of 100, 120, 180 and polishing buff, pumice slurry. All the acrylic samples were stored in deionised water for 48 hours at room temperature to facilitate the release of residual monomer.

2.4 Exposure of acrylic samples subjecting to denture cleansers:

Acrylic specimens were divided in to five groups with 10 (n=10) in each, based on the exposure to the denture cleansers. Among the groups one is a control group and the specimens in which were immersed in the distilled water (Selemp pharmaceuticals, India). The remaining four are the test groups, including immersion in four different denture cleansers, Fittydent denture cleanser,

Secure denture cleanser, Iodent overnight denture cleanser, and Efferdent overnight denture cleanser. The details of denture cleansers used in the study were presented in Table 1.

Table 1. The details of the disinfectants used in the study.

Commercial name	Mode of supply	Chemical composition (principal component)	Manufacturer
Efferdent overnight	Tablets	Potassium monopersulfate	Health care company,Medtech products Inc,USA
Iodent overnight	Tablets	Sodium bicarbonate	United exchange corp. USA
secure	Tablets	Sodium bicarbonate	Fittydent international GMBH,7423 Pinkfiled,Austria
Fittydent	Tablets	Sodium perborate monohydrate	Dr.REDDY'S LABORATORIES.LTD Hyderabad,India

Ten specimens were immersed in same container with the polished surface to be measured facing upward similarly for every subgroup. The denture cleansers tablets were prepared according to manufacturer recommendations, by adding one tablet to 200ml of warm water (40◦ C). Immersion time for Fittydent was 30 minutes, Secure denture tablets was 5 minutes, Iodent and Efferdent was 8 hours. After the immersion procedure, specimens were removed from the disinfectant solutions and thoroughly washed under running water and dried using absorbent paper. Again, the immersion procedure was repeated. Three immersions were performed every day for a period of 30 days simulating 90 days. Between the immersions the specimens were kept in distilled water at room temperature like the control group. Distilled water in the control group was changed every day for 30 days.

2.5 Surface roughness evaluation:

The surface roughness of the specimens was evaluated using surface profilometer (Surf test number SJ-201P, Germany). Three successive measurements were performed in different directions for each specimen and the average surface roughness (Ra) value was calculated (Figure 1).

Figure 1. Evaluation of surface roughness using surface Profilometer.

2.6 Evaluation of flexural strength:

The same acrylic specimens used for surface roughness evaluation were used for the flexural strength. The acrylic samples were then subjected to a three-point bending test in a universal testing machine (Figure 2) (Series 7200, DAK system Inc., Thane, India). The samples were supported by fixtures at a span length of 50 mm and the load was applied at a crosshead speed of 1mm/min until the specimen fractured. The fracture load was recorded in Newtons and flexural strength was calculated by the formula,

$S=3PL/2bd^2$

Where S=Flexural strength (MPa), P = Breaking load, L=distance between the supports, B=width of specimen (10 mm), D=specimen thickness.

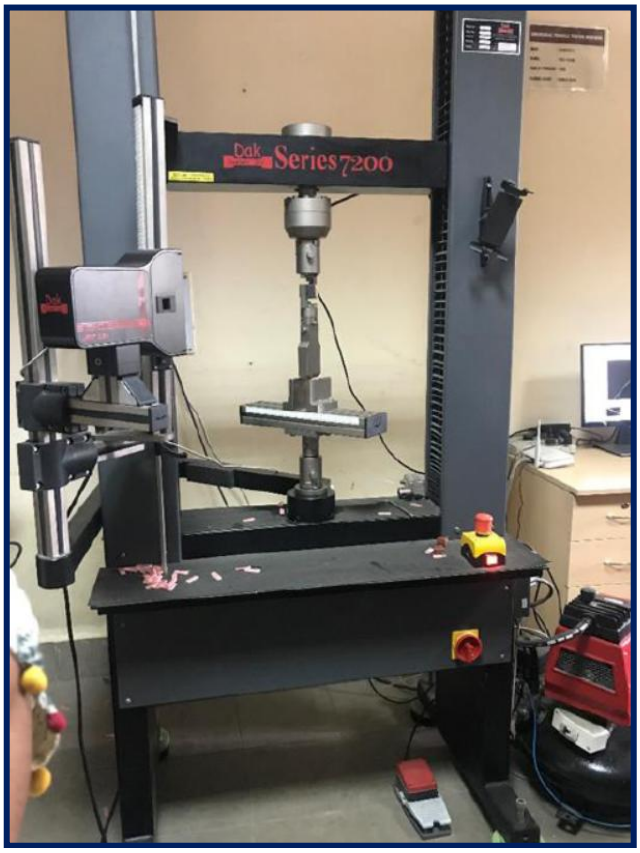

Figure 2. Universal testing machine.

2.7 Statistical analysis:

The data obtained were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) Version 21.0, IBM Corporation, USA. One-way ANOVA was used for intragroup comparisons, and the dependent t-test was used for assessing the significant differences in surface roughness between and after immersion in various disinfectants.

3. Results and discussion

3.1 Surface roughness:

The mean and standard deviations of surface roughness of denture base materials immersed in different disinfectant solutions at different time intervals are presented in Table 2. The immersion of denture base samples for 90 days demonstrated more surface roughness compared to the samples prior to the immersion in disinfectant solutions. Among the various disinfectants, Long-Efferdent demonstrated more Ra values followed by Long-Iodent, Short-Fittydent, and Short secure (Table 2). One-way ANOVA demonstrated a significant difference (p=0.0001) in the surface roughness (Ra) among disinfectants. The dependent t-test (Table 3) displayed significant difference in changes of the surface roughness (Short-Fittydent: p=0.0001; Short-Secure: p=0.0002; Long-Efferdent: p=0.0001; and Long-Iodent: p=0.0001) between before and after immersion of the specimens in various disinfectants except in the control group (p=0.4617).

Table 2: Surface roughness (Ra) of acrylic specimens before and after immersion.

Time Intervals	Groups	Mean (Ra)	Standard Deviation	Significance
Before immersion	Fittydent	1.04	0.31	0.9978
	Secure	1.02	0.46	
	Efferdent Overnight	1.02	0.36	
	Iodent Overnight	1.03	0.44	
	Control	1.08	0.44	
After immersion	Fittydent	2.75	0.63	0.0001*
	Secure	2.73	0.85	
	Efferdent Overnight	2.86	0.71	
	Iodent Overnight	2.80	0.55	
	Control	1.26	0.44	

* Significant difference

Table 3: Comparison of the changes in surface roughness scores before and after immersion (Dependent t- test).

Groups	Mean Difference	Standard deviation	Paired t-test	P-value
Fittydent	1.71	0.51	10.5388	0.0001*
Secure	1.71	0.79	6.8508	0.0002*
Efferdent Overnight	1.85	0.60	9.7532	0.0001*
Iodent Overnight	1.78	0.63	8.8693	0.0001*
Control	0.19	0.07	7.8450	0.4617

* Significant difference

3.2 Flexural Strength:

Immersion in different disinfectants resulted in a slight decrease in the flexural strength (Figure 1) compared to the control group (Short-Fittydent: 75.41± 7.62 MPa; Short-Secure: 75.72±9.72 MPa; Long-Efferdent: 74.74±10.37 MPa; Long-Iodent: 75.01±9.82 MPa; and Control: 76.03±7.95 MPa). However, one-way ANOVA demonstrated no significant differences (p=0.9994) among the specimens immersed in different disinfectants (Figure 1).

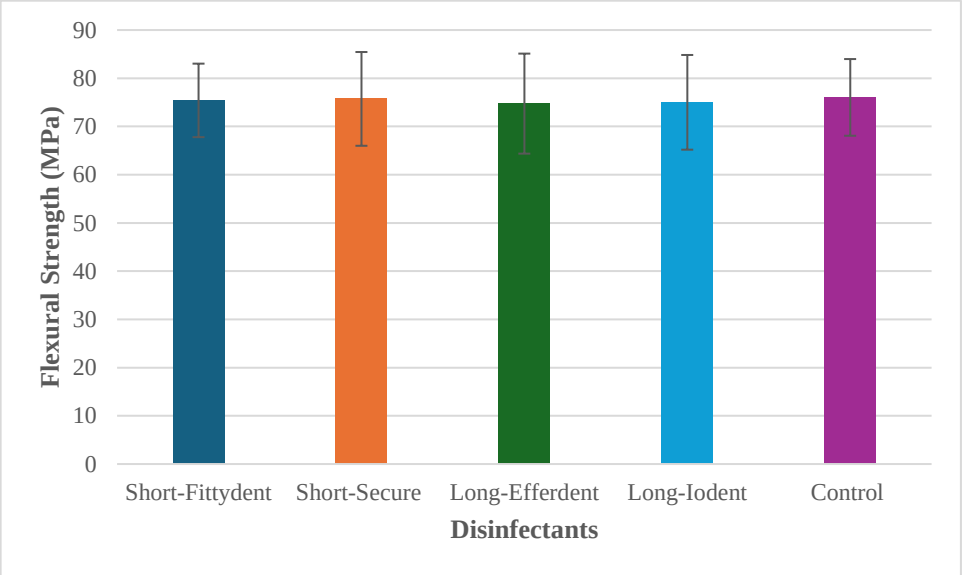

Figure 1. Flexural strength of acrylic specimens after immersion in different disinfectants for 90 days.

4. Discussion

4.1 Surface Roughness

Surface roughness (Ra) of acrylic specimens can be influenced by several factors including the chemical composition of the disinfectants, the duration of immersion, the concentration of the disinfectant solutions, and the interaction between the acrylic material and the disinfectants [13]. Acrylic resins, commonly used in denture bases, are susceptible to changes in surface properties when exposed to chemical agents [13,14]. These changes can affect the longevity, aesthetics, and comfort of the dentures.

Disinfectants contain various active ingredients that can interact differently with the acrylic surface. Denture cleansers cause loss of soluble component and plasticizers from the denture base resin. The higher ionic concentration of denture cleansers compared to water led to a higher release of soluble components. Further absorption of water and other ingredients by the denture base materials lead to surface roughness [15]. Exposure to oxidizing agents, alcohols, and chlorides can lead to surface degradation through chemical reactions such as oxidation or hydrolysis. In this study, the disinfectants used were Long-Efferdent, Long-Iodent, Short-Fittydent, and Short-Secure. The significant differences in Ra values indicate that these disinfectants have different effects on the acrylic surfaces. Literature reported that the disinfectants containing peroxide-based compounds can significantly alter the surface texture of acrylic materials [16]. In the present study, sodium bicarbonate, sodium perborate and Potassium monosulfate based disinfectants were used. Sodium perborate-based disinfectant may produce hydrogen peroxide on dissolving to exhibit antimicrobial activity, however, it may affect the surface quality of the denture prosthesis [17]. Potassium monosulfatedoes not directly release hydrogen peroxide (H_2O_2), but it produces similar oxidative effects through the generation of other reactive oxygen species. Also, these oxidating agents might have affected the surface roughness of the specimens. Sodium bicarbonate does not release hydrogen peroxide. Instead, it helps in disinfection by creating an alkaline environment that can inhibit the growth of certain bacteria and fungi [18]. However, alkaline solutions can cause saponification of the ester groups in acrylic resins, leading to surface degradation.

This chemical reaction can result in increased surface roughness over time [18].

Longer exposure times to disinfectants typically lead to more pronounced changes in surface roughness due to prolonged chemical interaction [19,20]. In the present study, 90 immersions performed over 30 days simulating 90days of immersion, indicating cleansing by the patient for a longer period. It was therefore decided to use an 8-hour period of immersion for Iodent and Efferdent tablets for testing these products. The acrylic specimens immersed in various disinfectants have demonstrated a significant surface roughness compared to the control. Similar to the present study, Neppelenbroek et al. (2005) reported that extended immersion in disinfectant solutions can exacerbate the roughening effects on acrylic resins [21].

Higher concentrations of disinfectants can enhance the chemical interactions with the acrylic surfaces, leading to greater changes in surface roughness. Although the specific concentrations used in this study are not provided, the differences in Ra values suggest that the disinfectants' efficacy and their impact on surface roughness were concentration dependent. According to a study by Machado et al., higher concentrations of chemical disinfectants result in more significant surface degradation of dental materials [22].

4.2 Flexural Strength

Flexural failure of denture base resin is considered the primary mode of clinical failure. Flexural strength is indicative of the compressive, tensile and shear strength which translates as stiffness and resistance of a material of to fracture [15]. Therefore flexural strength determines longevity and success of prostheses. According to ADA specification no 12, the minimum flexural strength value for denture base resins should be 65 MPa. However, the denture base material disinfected with various cleansing agents demonstrated more than 65 MPa. Higher flexural strength is crucial to the success of denture wearing, as alveolar absorption is a gradual and irregular process that causes uneven prosthesis support.

In the present study, the control group showed a slightly more flexural strength comared to the cleansing solutions groups. This decrease in flexural strength can be attributed to the interactions between the chemical components of the denture cleansers and the polymer chain backbone of the denture base materials that causing polymer degradation resulting in decreased flexural strength [23]. However, No significant differences were observed in the flexural strength among the groups ($p=0.9994$).

Similar to the present study, Vrinda R shah et al. demonstrated a decrease in the flexural strength of denture base materials on immersing in various denture cleansing solutions [24]. On the contrary, Prabal Sharma et al. found no significant change in the flexural strength of the denture base materials immersed in different cleasning agents compared to immersing in distilled water [23,25].

Studies reported that the composition of the denture cleansing solutions greatly alters the flexural strength of the denture base materials [7,23]. Peracini A. [7] and Motawea IT et al. [23] observed a decreased flexural strength in denture base materials immersed in potassium monopersulfate containing denture cleanser compared to immersion in distilled water. In the present study, the Efferdent demonstrated the lowest flexural strength among the groups and this decrease could be attributed to the presence of potassium monopersulfate in it.

This present in vitro study reported an increase in the surface roughness and a decreased flexural strength upon immersing in the denture cleansing solutions. The primary limitation of this in vitro study was that it did not fully replicate the dynamic conditions of the oral cavity, including tongue movements, saliva with fluctuating pH, and the presence of microorganisms. Additionally, only one type of denture base material was used, and the flat specimen surfaces do not account for the complex shapes of denture prostheses. The study also utilized denture cleanser tablets with varying immersion times as recommended by the manufacturers, and a longer testing period could better simulate long-term use, potentially revealing interactions with mechanical cleaning methods. Regarding the scope, this study focused on the action of effervescent denture cleansers on high-impact strength heat-polymerized acrylic resin, but further research incorporating biofilm models could offer additional insights. Future in vitro studies should aim to simulate the oral environment more closely, extend the testing duration, and investigate mechanical cleansing interactions. In vivo studies are needed to assess whether long-term use of denture cleansers may cause mucosal irritation or allergic reactions.

5. Conclusion:

Within the limitations of this in vitro study, it was observed that all specimens showed an increase in surface roughness after immersion, with control group specimens (immersed in distilled water) having lower surface roughness compared to those immersed in denture cleaning solutions. Long-term exposure to denture cleansers (overnight) led to higher surface roughness than short-term exposure. Among the cleansers, Efferdent overnight tablets caused the greatest surface roughness, while Secure tablets resulted in the least. In terms of flexural strength, the control group had the highest mean values after immersion, although no statistically significant differences were found among the test groups.

References:

1. Alla R, Raghavendra KN, Vyas R, Konakanchi A. Conventional and contemporary polymers for the fabrication of denture prosthesis: part I–overview, composition and properties. Int J Appl Dent Sci. 2015;1(4):82-9.
2. Alla RK, Sajjan S, Alluri VR, Ginjupalli K, Upadhya N. Influence of Fiber Reinforcement on

the Properties of Denture Base Resins. J BiomaterNanobiotechnol. 2013;4:91-7.
3. 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 Ind Prosthodont Soc. 2017;17(1):61-7.
4. Gornitsky M, Paradis I, Landaverde G, Malo AM, Velly AM. A Clinical and Microbiological Evaluation of Denture Cleansers for Geriatric Patients in Long-Term Care Institution. J Canadian Dent Assoc. 2002;68(1):39-45.
5. Swamy KN, Alla RK, Mohammed S, Konakanchi A. The role of antifungal agents in treating denture stomatitis. Res J Pharm Technol. 2018;11(4):1365-9.
6. Senna PM, Vieira AP, Sotto-Maior BS, Silva WJ, Del Bel Cury AA. Influence of immersion time of denture cleansers on the surface roughness of resilient denture liners.Rev Odonto Cienc. 2011;26:35-9.
7. Peracini A, Davi LR, de Queiroz Ribeiro N, de Souza RF, da Silva CH, Paranhos HD. The effect of denture cleansers on physical properties of heat - polymerised acrylic resin. J Prosthodont Res. 2010;54(2): 78-83.
8. Jeyapalan K, Kumar JK, Azhagarasan NS. Comparative evaluation of the effect of denture cleansers on the surface topography of denture base materials: An in-vitro study. J Pharm Bioallied Sci.2015; 7(Supp2):S548-53, 2015.
9. Alla RK, Swamy KN, Vyas R, Konakanchi A, Guduri V, Gadde P. Influence of silver nanoparticles incorporation on flexural strength of heat-cure acrylic denture base resin materials. Annual Res Rev Biol. 2017;17(4):1-8.
10. Alla RK, Swamy KN, Vyas R, Tiruveedula NB, Raju AM. Physical and mechanical properties of heat activated acrylic denture base resin materials. Annual Res Rev Biol. 2017;11(6):2258-62.
11. Alla RK. Denture Base Materials (in) Dental Materials Science. 1st edition, Jaypee Medical Publishers Pvt. Ltd., India, 2013, 248-28.
12. ISO 20795-1:2013; Dentistry—Base Polymers—Part 1: Denture Base Polymers. International Organisation for Standardization:Geneva, Switzerland, 2013.
13. Haghi HR, Asadzadeh N, Sahebalam R, Nakhaei M, Amir JZ. Effect of denture cleansers on color stability and surface roughness of denture base acrylic resin. Ind J Dent Res. 2015;26:163-6.
14. Baba Y, Sato Y, Owada G, Minakuchi S. Effectiveness of a combination denture-cleaning method versus a mechanical method: comparison of denture cleanliness, patient satisfaction, and oral health-related quality of life. J Prosthodont Res. 2018;62(3):353-358.
15. Essop AR, Motloba D, Morweng RP. Effect of denture cleansers on flexural strength of heat polymerized and auto-polymerized acrylic resins. South African Dent J. 2016;71(1): 518-21, 2016.
16. Buergers R, Rosentritt M, Schneider-Brachert W, Behr M, Handel G, Hahnel S Efficacy of denture disinfection methods in controlling Candida albicans colonization in vitro. Acta Odontologica Scandinavica. 2008;66(3):174-80.
17. Carvalho CF, Vanderlei AD, Salazar Marocho SM, Pereira S, Nogueira L, Arruda Paes-Junior TJ. Effect of disinfectant solutions on a denture base acrylic resin. Acta Odontológica Latino Americana. 2012;25(3):255-60.
18. Azevedo A, Machado AL, Vergani CE, Giampaolo ET, Pavarina AC, Magnani R. Effect of disinfectants on the hardness and roughness of reline acrylic resins. J Prosthodont. 2006;15(4):235-42.
19. Polyzois GL, Zissis AJ, Yannikakis SA. The effect of glutaraldehyde and microwave disinfection on some properties of acrylic denture resin. Int J Prosthodont. 1995;8(2):150.
20. Bulut AC, Türksayar AA. Effect of Eight Different Disinfection Methods on the Surface Roughness and Flexural Strength Properties of Acrylic Resins: In Vitro Study Turkiye Klinikleri J Dent Sci. 2023;29(1):139-46.
21. Neppelenbroek KH, Pavarina AC, Vergani CE, Giampaolo ET. Effect of disinfectants on the hardness and roughness of reline acrylic resins. J Prosthet Dent. 2005;(15(4):171-6.
22. Machado AL, Giampaolo ET, Vergani CE, Souza JF, Jorge JH. Changes in roughness of denture base and reline materials by chemical disinfection or microwave irradiation. Surface roughness of denture base and reline materials J Appl Oral Sci. 2011;19:521-8.
23. Motawea I, Gamal El Deen H, Eltayeb H. Effect of denture cleansers on flexural strength, color stability and surface roughness of flexible and microwave cured acrylic resin. Al-Azhar Dental Journal for Girls. 2017;4(3):311-23.
24. Shah VR, Shah DN, Chauhan CJ, Doshi PJ, Kumar A. Evaluation of flexural strength and color stability of different denture base materials including flexible material after using different denture cleansers. J Ind Prosthodont Soc. 2015;15(4):367-73.
25. 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. Journal of clinical and diagnostic research: JCDR. 2017 Aug;11(8):ZC94.