Evaluation of the Effect of Denture Cleansers on the Surface Roughness of Hard Denture Base Material: An In vitro Study

Abstract

Background: Maintaining the oral hygiene of denture wearers is a challenge faced in modern dentistry. Biofilm formed on dentures has been associated with denture stomatitis, malodor, aspiration pneumonia, infectious endocarditis, gastrointestinal infection, and chronic obstructive pulmonary disease. Objective: The purpose of this study was to evaluate the effect of denture cleansers on the surface roughness of hard denture base material. Materials and Methods: A total of 100 heat-cure acrylic resin specimens were fabricated with dimensions 30 mm × 15 mm × 3 mm in length, width, and thickness, respectively. All specimens were distributed into four groups randomly. Three commonly prescribed denture cleansers were used for immersion in this study. Regular tap water was used for immersion in the control group. Surface roughness was determined before immersion and after immersion in denture cleansing solutions using contact profilometer. The data were subjected to statistical analysis using paired t-test, one-way analysis of variance, and Tukey’s multiple post hoc test. Results: The change in surface roughness of acrylic samples immersed in Clanden group was statistically significant (P < 0.05) at individual group level. However, the change in surface roughness of acrylic samples after immersion, when compared between the groups, namely, control, Clinsodent, Clanden, and Fittydent, was not statistically significant (P > 0.05). Conclusion: Within the limitation of this study, the three denture cleansing materials, namely, Clinsodent powder, Clanden tablet, and Fittydent tablet, are safe to be prescribed as denture cleansers.

Keywords: Acrylic resin, denture cleanser, denture hygiene, surface roughness

Introduction

Maintaining hygiene of dental tissues and dentures is a significant challenge for dentistry. Biofilm on dentures has been associated with denture stomatitis, malodor, aspiration pneumonia, infectious endocarditis, gastrointestinal infection, and chronic obstructive pulmonary disease.

The denture base after processing is finished using acrylic finishing bur and sandpaper and polished using a rag wheel and cone with pumice slurry. The surface roughness of the denture base material has a substantial effect on plaque adherence and microbial colonization of the prostheses. A rough surface creates niches in which microorganisms are protected against mechanical dislodging forces. The bacteria can subsequently spread over the denture surface from these niches. It has been proven that an increase in surface roughness above a threshold of 0.2 µm results in a simultaneous increase in plaque accumulation.[1]

The denture cleansing and plaque elimination methods employed by a vast majority of patients are restricted to either rinsing under running water or brushing using normal toothbrush and toothpaste. These simple forms of plaque elimination are relatively insufficient and may not satisfactorily eliminate the accumulated microorganisms or fungal colonies from the denture surfaces. Hence, more definitive cleansing methods or protocols are recommended to effectively maintain a disease-free oral environment.[2]

The two major approaches used for denture cleaning are mechanical and chemical methods. Mechanical methods include brushing (using water, soap, toothpaste, or abrasives) and ultrasonic treatment. Mechanical cleaning with brushes is inexpensive and common, but elderly and disabled patients might face difficulties with this method because of poor motor coordination, poor dexterity, and low motivation. There is evidence that mechanical cleaning with toothpastes...
can result in significant wear of conventional acrylic resins.\(^3\)

Chemical method includes immersion of dentures in different cleansing solutions. Immersion in cleansing solution is an inexpensive, easy, and comfortable alternative procedure. Moreover, the cleansing solution can reach undercuts of the denture base that are difficult to clean mechanically, resulting in more efficient cleaning.\(^3\)

Chemical cleansers are useful alternatives to brushing among geriatric or disabled denture patients. Some of these cleansers contain chloride ions that can cause corrosion of base metal components.\(^4\) Hence, this study was undertaken to evaluate any change in the surface roughness of hard denture base materials following immersion in commonly prescribed chemical cleansing materials. It was hypothesized that there is no change in the surface roughness of hard denture base material after immersion in powder and tablet-based denture cleansers.

**Materials and Methods**

**Custom-made die**

A customized two-piece die [Figure 1] was fabricated which consisted of an upper and lower member. The upper member contained five mold spaces of dimensions (30 mm × 15 mm × 3 mm).\(^4\) This was placed over the lower member which in turn formed the base. Petroleum jelly (Bioline White Petroleum Jelly, Biopharm Laboratories, Bangalore) was applied into the mold, following which molten modeling wax (The Hindustan Dental Products, Hyderabad) was flown into the mold spaces. Once the modeling wax hardened, the wax blocks were retrieved from the mold and used to fabricate the acrylic resin specimens.

**Preparation of the acrylic resin specimens**

A total of 100 heat-cure acrylic resin specimens were fabricated. The wax blocks of dimensions (30 mm × 15 mm × 3 mm)\(^4\) in length, width, and thickness, respectively, were invested in a dental flask using the two-pour technique. Dental plaster (Asian Chemicals, Rajkot) was used for investing the wax specimens. Once the gypsum material had completely set, wax elimination procedure was carried out. The resultant 100 molds were cleaned thoroughly with hot soapy water and were used to fabricate the acrylic specimens.

Separating media (DPI heat-cure cold mold seal) were applied on the upper and lower members of the flask. Conventional heat-processed polymethyl methacrylate denture base resin (DPI heat-cure denture base material) was mixed in a porcelain jar according to manufacturer’s recommended ratio (24 g polymer to 10 ml of monomer). The resin in the dough stage was kneaded thoroughly and packed in the mold space. Trial closure was done and excess flash was removed. The flask was closed under 2 MPa pressure in a bench press and bench cured for 60 min at room temperature. Resin was polymerized using the conventional compression molding technique in an acrylizer C-73A (Confident Dental Equipments Pvt Ltd, Bangalore) at 74°C for 2 h followed by boiling at 100°C for 1 h. After the curing cycle was completed, the flask was bench cooled to room temperature before deflasking. The test specimens were carefully retrieved from the molds.

**Finishing and polishing of acrylic resin specimens**

Initially, all specimen surfaces were trimmed using fine-grade tungsten carbide bur (Essen Engineers, Mumbai). The surface to be checked for surface roughness was smoothened using 120 grit sandpaper (Arpees Abrasives Pvt Ltd), and each specimen was polished using a rag wheel and a felt cone with pumice slurry for 15 s at the rate of 2800 rpm. The specimens were immersed in water for 24 h to remove residual monomer before measurements.

All the specimens were numbered from 1 to 100 on the rough surface for distribution among four groups randomly and to enable comparison between each evaluation. The samples were grouped into four groups each consisting of 25 samples as follows:

- **Group 1— Control group (tap water)**
- **Group 2— Clinsodent powder group (ICPA Health Products Ltd, Ankleshwar)**
- **Group 3— Clandent tablet group (Vovantis Laboratories Pvt Ltd, Vadodara)**
- **Group 4— Fittydent tablet group (Group Pharmaceuticals Ltd, Thane).**

**Preparation of denture cleansing solution**

Regular tap water was used as immersing solution for the control group. Powder-based denture cleanser solution was prepared by adding a tablespoon of powder to 100 ml of tap water as per the manufacturer’s instructions. Tablet-based denture cleanser solution was prepared by placing a tablet in 100 ml of tap water [Figure 2]. The specimens were immersed into the prepared denture cleansing solutions for
8 h to mimic the overnight soaking of the denture by the patient.

Testing of samples for surface roughness

The surface roughness (in µm) was analyzed with a surface roughness profilometer (Mitutoyo SJ-210, Mitutoyo Corporation, Tokyo, Japan) having a diamond stylus (tip radius 5 µm) [Figure 3]. The surface roughness is the arithmetic average of the absolute values of the measured profile height of surface irregularities and measured from a mean line within a preset length of the specimen. The profilometer was set to move the diamond stylus across the specimen surface under a constant force of 4 mN. A measurement was obtained from the stylus passing across a length of 4 mm at 0.5 mm/s to the nearest of 0.01 µm. The cutoff length was 0.8 mm. An orientation jig was fabricated to position the stylus of the profilometer in the same location on the specimen for repeated measurements. Three measurements of surface roughness were performed for each sample at the same position, and an arithmetic mean value was calculated.

Surface roughness of acrylic samples was obtained before immersion and after immersion in denture cleansing solutions.

Results

Table 1 shows the mean surface roughness of the samples and standard deviation of all the groups. Clinsodent group showed the least difference from initial to after, i.e., 0.0049 ± 0.1366, whereas Clanden group showed the maximum difference, i.e., 0.0553 ± 0.1204. The data obtained were validated using Kolmogorov–Smirnov test. It was found that the values followed a normal distribution and were further analyzed using parametric tests.

Table 2 shows the comparison of initial and after surface roughness (in µm) scores in four study groups (Control, Clinsodent, Clanden, and Fittydent) by paired t-test. A $P = 0.05$ or less was considered statistically significant. No significant changes in roughness were found for control, Clinsodent, and Fittydent groups ($P > 0.05$). The Clanden group presented a significant increase in roughness ($P = 0.0306$).

Discussion

Maintaining good oral and prosthesis hygiene is a common problem encountered by dentists in patients using dental prosthesis. *Candida albicans* infection is a common finding in people with poor denture hygiene. Particles of food entrapped between the denture and the denture-bearing tissues allow multiplication of microorganisms, resulting in mucosal injury, flabby hyperplastic tissue, chronic mucosal irritation, denture stomatitis, and multiple papillomatosis. This problem is compounded in geriatric patients due to lack of motivation and basic knowledge on hygiene maintenance or physical limitations.[1-5]

The surface finish of the denture base resin plays a role in bacterial growth, which in turn affects the health of tissues contacting the denture base. Rough surfaces promote plaque accumulation and colonization of bacteria.[6] The adherence of microorganisms on the surface of hard acrylic resins is
the first step for the colonization and development of an oral infection in denture wearers. Therefore, acrylic should have the smoothest surface possible to reduce biofilm formation. This in turn will reduce mucosal inflammation and facilitate denture cleaning. These rough surfaces can be avoided by proper finishing of dentures, which involves both abrading and polishing.

The materials used for finishing and polishing denture base are primarily abrasives. Finishing abrasives are hard and coarse abrasives that are used for removing gross irregularities on the surface, whereas polishing abrasives have finer particle sizes and are used to smoothen surfaces that have been roughened by finishing abrasives. Serra et al. found that the acrylic resin surface can be finished and polished using multilaminated burs, wood sandpaper, water sandpaper, pumice, and low abrasive liquids. The results of the study conducted by Al-Rifaiy showed that mechanical polishing produced smoother surfaces than chemical
polishing.⁴ The denture base material used in this study after processing was finished using fine-grade tungsten carbide bur and 120 grit sandpaper and polished using a rag wheel and a felt cone with pumice slurry.

Denture cleaning methods include mechanical and chemical cleaning and microwave irradiation. Mechanical cleaning includes the removal of plaque using a toothbrush or ultrasonic bath. Denture brushing can be carried out by rinsing under running water and using soap or toothpaste, which dislodges debris and plaque adherent to the surface. Chemical cleaning products are based on sodium hypochlorite, peroxides, and neutral peroxides with enzymes or acids. An ideal chemical denture cleanser has to be nontoxic, bactericidal, and fungicidal; has to be harmless to the structure of denture; should effectively remove organic and inorganic deposits; and should be easy to use. Among the various methods, mechanical cleaning is an effective measure to clean dentures and maintain a healthy mucosa.⁹

However, in geriatric or handicapped patients who are denture wearers as their manual dexterity may be compromised, chemical denture cleansers can be a better alternative. The use of microwave-associated radiation has also been suggested to disinfect dentures, but due to lack of standardization, studies discourage the use of this method as routine denture hygiene measure.¹⁰ Machado et al. found that brushing resulted in an increase in surface roughness for Lucitone.¹¹ Srinivasan and Gulabani reported that the use of chemical-based denture cleansers reduced the microbial numbers as compared to plain manual cleansing methods in complete dentures.² An immersion-type or chemical-based cleanser was found to be the most suitable cleanser because of its low abrasivity and effective removal of organic debris.¹²

Chemical-based denture cleansers do not contain abrasive particles. One of the main cleansing agents in this category is effervescent peroxide or sodium hypochlorite. The oxygen released effectively dislodges debris and creates a surface free of plaque.¹² Duyck et al. did a crossover randomized clinical trial and concluded that the use of cleansing tablets during overnight denture storage reduced the total bacterial count on acrylic removable dentures as compared to overnight storage in water.¹³ This type of cleansers is good in their cleansing efficiency but can lead to deterioration of the denture base material such as bleaching of acrylic resin, corrosion of metal, and deterioration of soft lining materials if used incorrectly.¹⁴ The research work of Pinto et al. stated significant increase in surface roughness after repeated cycles of chemical disinfection.¹⁵

This study has evaluated the effect of denture cleansers on the surface roughness of hard acrylic resin. The results demonstrated that there was not much difference in the mean surface roughness between preimmersion and postimmersion values. Although there was a reduction in the mean score of the Fittydent cleansing group, the difference was not of statistical significance. The changes in surface roughness exhibited in all the groups, including the initial results and those after immersion, were lower than the results reported by Zissis et al. (0.7–4.4 μm).¹⁶ who investigated the surface characteristics of 20 denture materials including hard acrylic resins.

The statistical analysis using paired t-test indicated a significant (P < 0.05) increase in the surface roughness of Clanden denture cleanser group, while the change in surface roughness observed was not statistically significant in the other groups at individual group level. One-way ANOVA and Tukey’s multiple post hoc tests were done to compare the changes between the four groups before and after immersion in the cleansing solution. The changes were not statistically significant (P > 0.05) between the groups. Thus, the results obtained in the present study showed that the null hypothesis was rejected. Jeyapalan et al. found that there was no significant change in surface roughness for the short duration of immersion, whereas changes were seen as the immersion periods were increased.¹⁷ The results of a study done by Azevedo et al. showed that the disinfectant solutions caused no apparent damage on the roughness of the materials evaluated.¹⁸ The findings of this study are in agreement with the findings of Jeyapalan and Azevedo.

Studies have shown that when the surface roughness increases by a value of 0.2 μm,² then the bacterial colonization increases.²⁰ In this study, the mean change in surface roughness after immersion in cleansing solutions was found to be 0.03 μm, which is not even close to the threshold surface roughness for bacterial retention. The findings of this study indicated that all the three denture cleansing materials are safe for usage as immersion-type denture cleansers. Further studies are required to study the effect of different finishing methods and longer immersion time for changes in surface roughness using a variety of denture base resins.

Conclusion
Within the limitation of this study, these three denture cleansing materials, namely, Clinso dent powder, Clanden tablet, and Fittydent tablet, are safe to be prescribed as denture cleansers. Further studies are needed with respect to longer immersion time and different finishing methods.

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Conflicts of interest
There are no conflicts of interest.

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