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To Compare and Evaluate The Effect of Commercially Available Denture Cleansers on the Color Stability, Flexural Strength and Surface Roughness of Two Different Types of Denture Base Materials -An in-Vitro Study

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Abstract

Aim: The Purpose of this in Vitro Study was to compare and evaluate the effect of commercially available denture cleansers on the color stability, flexural strength and surface roughness of two different types of denture base materials.

Materials and Methods: In order to conduct this study a metal mould with specific dimensions were fabricated to make the heat cure acrylic and polyamide Lucitone denture base specimens. A total of 160 samples were included in the study which were divided on the basis of denture base materials into two groups: Group 1 Heat cure acrylic denture base resin and Group 2: Polyamide resin- Lucitone denture base resin. Group 1 and Group 2 were further divided into 4 subgroups based on the different denture cleansers. Sample of heat cure acrylic

resin and polyamide resin –Lucitone of specific dimensions will be prepared using modelling wax and metal mould. Three types of commercially available denture cleansers will be prepared as per manufacturer's instructions. After 90 days of immersion period, samples were subjected to spectrophotometer for color stability test, Surface roughness tester and universal testing machine under 3-point loading to check for the flexural strength of the specimens. The data collected will be subjected to statistical analysis.

Results: To compare the data of these groups, it was preferred to apply one way ANOVA and POST HOC TEST for testing the difference of mean in between the groups. The level of significance was set at P- value $\leq$ 0.05. Among all the three denture cleansers used in our study group1{acrylic resin} showed statistically minimal reduction in values of flexural strength with Fittydent in comparison to Secure and Clinsodent. Similarly group2 {Lucitone- polyamide resin} showed statistically minimal reduction in values of flexural strength with Fittydent in comparison to Secure and Clinsodent. On immersion of specimens of both the groups in Clinsodent, Fittydent, and Secure denture cleansers, reduced flexural strength of the heat-cured acrylic resin and Lucitone- polyamide resin was observed in comparison to distilled water. In this study acrylic resin group exhibited change in surface roughness which was seen maximum with Clinsodent. Surface roughness of acrylic resin with Clinsodent and Secure was camparable. Fittydent showed least change in surface roughness in camparison with control group. Similar result pattern was observed in lucitone- polyamide group. ANNOVA and POST HOC TEST showed the result to be satisficing when three commercially available denture cleanser were taken into consideration.

Keywords: Denture Cleanser, Sodium Perborate, Biofilm, Denture base resin, Lucitone, Oral hygiene

Introduction

Denture base resins have been widely used to fabricate dentures due to their acceptable and desirable characteristics such as aesthetics, easy handling, and low permeability to oral fluids and color stability. Several types of denture base resins like heat polymerized polymethyl methacrylate resin (heat polymerized PMMA resin), auto polymerized polymethyl methacrylate resin (auto polymerized PMMA resin), and visible light polymerized urethane dimethacrylate resin (visible light polymerized UDMA resin), are often used for prosthetic purposes. Flexible denture base material is gaining importance in recent times, which is chemically a polyamide (nylon based polymer).

Complete dentures are daily exposed to normal oral and microbial flora, which include bacteria, viruses and fungi[1.] These microorganisms may also cause systemic and local infections. Efficient and regular hygiene is important for the long-term upkeep of complete denture and is indispensable for the general health of edentulous people. The denture can be cleaned mechanically, chemically, or by the combination of these methods. Mechanical method is routinely and widely used by the patients but many elderly patients are not able to follow it because of lack of compliance and poor motor coordination due to age and hence, the use of chemical denture cleansers becomes a viable option for such patients [2.]

Different types of chemical solutions have been recommended for denture disinfection. An ideal denture cleanser should be biocompatible, bactericidal, fungicidal, harmless, and nontoxic to the structure of denture; should effectively remove deposits; and should be easy to use. Denture cleansers can be oxidizing agents

(alkaline perborates), reducing solutions (sodium hypochlorite), effervescent agents (perborates and carbonates), chelating agents (ethylenediaminetetraacetic acid), detergents (sodium polyphosphate), enzymes (protease, amylase), and disinfectants (glutaraldehyde[).] The most commonly used among these are alkaline peroxides[3.]

However, use of commercially available denture cleanser also effects the properties of the denture base resin such as color stability. Color changes may indicate aging or damaged dental materials. Discoloration of denture base resins results in an aesthetic problem, and the denture base polymer should have good aesthetics with a smooth and glossy surface and be capable of matching the natural appearance of the soft tissues. Color stability of denture base resins may provide important information on the serviceability of the materials [4.]

Thus the purpose of this study is to compare and evaluate the effect of commercially used denture cleansers on the color stability, flexural strength, and surface roughness on two different types of denture base materials.

Methodology

In order to conduct this study a metal mould with specific dimensions of 9 mm X 36 mm X 2 mm was fabricated using CAD technique. Four rectangular spaces were cut in central portion of the metal body. This metal mould was used to make the heat cure acrylic and polyamide Lucitone denture base specimens. A total of 160 samples were included in the study which were divided on the basis of denture base materials into two groups: Group 1 Heat cure acrylic denture base resin and Group 2: Polyamide resin- Lucitone denture base resin. Group 1 and Group 2 were further divided into 4 subgroups based on the different denture cleansers.

Preparation of the specimen

Sample of heat cure acrylic resin and polyamide resin – Lucitone of specific dimensions were prepared using modelling wax and metal mould. A thin layer of petroleum jelly was applied on the inner surface of die slot created in the metallic block and base. Modelling wax was melted using a wax bath and poured into the mold space. Once the space was filled, it was covered with glass slab. Any discrepancy in the size and shape of the wax block was corrected by either pouring or eliminating wax and cooled. After 15 min the base and glass slab were removed. The completely hardened wax blocks were kept at room temperature for 5 minutes and were then invested in plaster to fabricate the Poly methyl meth acrylate resin samples. These wax blocks were invested in the denture flask using dental plaster following the manufacturer instructions for water/ powder ratio, mixing time and setting time. Dewaxing was done by keeping the flask in the boiling water.

The material used was conventional heat polymerized denture base material (DPI) for group 1 and polyamide Lucitone for group 2. The polymer and monomer were mixed in ratio of 3:1 by volume (45 mg+15ml). Flasks were closed with the cellophane sheet in between them for trial closure in hydraulic press under 20 KN pressure. The flasks were clamped and final closure was done under pressure of 20 KN for 30 min. The flask was immersed in water in an Acrylizer containing water at room temperature and processing was done according to manufacturer recommendations.

After overnight bench cooling, cured specimens were carefully removed and deflasked. They were trimmed and polished using progressive grits of sand paper and buffs, finally ensuring that the dimensions of 9 mm X 36 mm X 2 mm were maintained. The samples were stored

in distilled water for 24 hours so as to reduce the residual monomer content.

Preparation of denture cleansers

Three types of commercially available denture cleansers were prepared as per manufacturer's instructions.

Immersion of the samples

Group 1: **Heat Cure Acrylic Resin**

Control Group: Specimen were immersed in distilled water for 90 days changing the distilled water every 24hrs.

Denture Cleanser groups: 20 Specimens in each group were immersed in the respective denture cleanser solution (fittydent, secure, and clinsodent) for 8hrs every day for 90 days. After immersion in denture cleanser, the specimens were washed thoroughly with water and then kept in distilled water until next soaking cycle.

Group 2: **Polyamide resin – Lucitone**

Control Group: 20 specimens were immersed in distilled water for 90 days changing the distilled water every 24hrs.

Denture Cleanser groups: 20 specimens each were immersed in the respective denture cleanser solution (Fittydent, Secure, and Clinsodent) for 8hrs every day for 90 days. After immersion in denture cleanser, the specimens were washed thoroughly with water and then kept in distilled water until next soaking cycle.

Testing of specimen for Color Stability

After 90 days of immersion period, samples were subjected to spectrophotometer for color stability test. The reflectance value of these samples at wavelength ranging from 380 to 740 nm were recorded using Elico SP 150 spectrophotometer by measuring the absorbance and transmittance values and reflectance curves were obtained. After 90 days of immersion period, samples will be subjected to Surface roughness tester and universal testing machine under 3 point loading to check for the flexural strength of the specimens.

Statistical Analysis

Collected data was entered into Microsoft excel 2016. The data analysis was done using SPSS 26.0. Descriptive statistics was compiled. To compare the data of these groups, it was preferred to apply one way ANOVA and POST HOC TEST for testing the difference of mean in between the groups. The level of significance was set at P- value ≤ 0.05.

Discussion

As age advances, the rate of complete and partial edentulism is likewise increasing. In this way, the utilization of removable prosthesis has increased among the older adults[5]. Oral health and general well-being of the patient is also affected by edentulism. The placement of denture causes many changes in the oral environment and adversely affects the integrity of the oral tissues[6]. The patient experiences reduced chewing efficiency and denture-related oral lesions such as angular cheilitis, traumatic ulcer, and denture stomatitis. An ideal denture base material should have adequate mechanical and physical properties, besides biocompatibility and aesthetics. The post-insertion instructions given to the patients are most critical for maintaining oral mucosal health and longevity of the prosthesis. As we know, the denture surface itself can produce a number of favorable changes for the accumulation of bacteria and yeast. The intaglio surface of the dentures usually shows micropits and microporosities, which makes it possible for the yeast to nest[7].

Therefore, the mechanical methods were employed for cleaning the denture but were found to be ineffective in removing the microorganisms completely from the denture surface because of lack of compliance and poor motor coordination due to age. So, mechanical methods

were utilized in conjugation with magnetic stirrers, agitators, sonic vibrators, and ultrasonic devices, yet at same time failed to demonstrate total adequacy in cleaning dentures[8].

This led to use of the chemical cleansers as adjunct to mechanical cleaning methods. Chemical cleaners are available in form of creams, pastes, gels, solutions, and tablets. They may include one or combination of various chemical agents such as sodium hypochlorite, enzyme, chlorhexidine, alkaline peroxidase, and diluted acids as the immersion medium for denture cleaning. But, some chemical agents have been reported to damage acrylic resin by altering the surface properties of the acrylic resin if used for a longer time without following manufacturer's instructions[9.]

The prime physical properties affected by the use of denture cleansers are the flexural strength of acrylic resin. They result in clinical failure of the prosthesis by producing flexural fatigue and increase the risk of intraoral and extraoral fracture of dentures[10].

Another important property influenced by use of denture cleansers is the surface roughness. It commonly aids in biofilm formation by providing rough irregular areas for retaining the debris and microorganisms. Increased surface roughness can make removal of the biofilm more difficult.

Surface color of the prosthesis is also affects by use of denture cleansers, disturbing the patient the most. It is an indicator of ageing or damage to dental materials. It provides information on serviceability of the material.

This study was undertaken to investigate how different commercially available denture cleansers affect above-mentioned properties of the heat-cured resin as most of them were readily available over the counter, also to determine the most suitable denture cleanser for heat cure-based denture bases[11].

Ideally, immersion in the chemical denture cleanser should not alter the physical, mechanical, and chemical properties of the denture-based acrylic resin. But on contrary, use of these agents do result in changes in surface morphology and flexural strength of denture resins.

However, several studies revealed that the physical, mechanical, and chemical properties of the acrylic resin are affected by denture cleanser.

The primary reason for clinical failure of the prosthesis is flexural fatigue of the denture base. The flexural three-point bending test is performed on denture resin because it generates similar type of stresses as applied to the denture during mastication. As reported by various authors, after complete polymerization reaction, some amount of residual polymethyl methacrylate monomer content remains, which acts as a plasticizer and reduces the interchain forces and yield in early deformation under load which result in reduced flexural strength of denture base acrylics.

To remove this residual monomer, Harrison and Huggett[12] recommended use of long water bath cycles with terminal boil as it will reduce the levels of the residual monomer by approximately three times. For residual monomer elimination, the specimens of this study were immersed in distilled water. Also the standard acrylization procedure was followed to prepare all acrylic specimens.

Among all the three denture cleansers used in our study group1 {acrylic resin} showed statistically minimal reduction in values of flexural strength with Fittydent in comparison to Secure and Clinsodent. Similarly group2 {Lucitone- polyamide resin} showed statistically minimal reduction in values of flexural strength with Fittydent in comparison to Secure and Clinsodent. Smith et al.[13] explained that if polymerized acrylic resins are

immersed in the immersion medium for a longer period, they tend to absorb water continuously which act as a plasticizer reducing the strength of the resin.

Beyli et al.[14] also stated that water sorption by acrylic resin resulted in dimensional instability and fatigue of acrylic resin leading to crack formation and subsequent fracture of the denture. On immersion of specimens of both the groups in Clinsodent, Fittydent, and Secure denture cleansers, reduced flexural strength of the heat-cured acrylic resin and Lucitone- polyamide resin was observed in comparison to distilled water immersion in the present study.

Ragher M et al. also found out that denture cleansers altered the flexural strength of heat polymerized acrylic resins that endured soaking cycles which simulated 180 days of use of commercially available denture cleanser[15].

In a study conducted by Porwal A et al. denture base resin exhibited a change in color, surface roughness and hardness to some degree. Polyamides resin immersed in sodium perborate showed a maximum change in color after immersion for 180 days. The study also exhibited that conventional heat cure resin immersed on sodium hypochlorite showed a maximum change in surface roughness and conventional heat cure immersed in sodium perborate showed a maximum change in hardness. It was concluded that denture cleanser for different cleanser for different denture base resins should be based on the chemistry of resin, denture cleanser concentration, and duration of immersion.

Color stability is an important property of denture base acrylic resin. Color changes indicate aging or damaged dental materials. A significant color change on immersion of denture base resin and polyamide resin in commercial denture cleanser was noticed in this study, with the maximum color change with Fittydent, followed by Secure and Clinsodent in both the groups in camparison to control group. However chemical denture cleanser used according to the manufacturers' specifications did not cause flexural strength alterations or color stability on heat polymerized acrylic resins submitted to soaking cycles simulating 30 days of use , was exhibited in a study conducted by Sato S et al.[16]

In this study acrylic resin group exhibited color change which was maximum in the Fittydent group, followed by Secure, and Clinsodent in camparison to control group. Similar results were seen in the Lucitone polymide group in comparison to the control group.

According to Robinson et al., Saraç et al., and Purnaveja et al.[17], it was concluded that the solvent present initially penetrates into the intermolecular polymer network and causes expansion of the intermolecular spaces due to water sorption in acrylic resin materials, facilitating leaching out of the intrinsic pigments and penetration of extrinsic colorant in denture cleaning solution which can also cause color change. This could be the probable cause that the acrylic resin used in the study tends to change color as a result of leaching out of the coloring material from the acrylic surface with long-term immersion in distilled water. Later opacity of acrylic resin occurs as a result of monomer leaching out and water getting absorbed on to the surface.

In this study secure and clinsodent showed less color change in camparison to fittydent in both groups. Whitening of all acrylic resin occurs due to qualitative difference or pH difference of the cleaning solution. Unlü et al.[18] also observed the whitening effect of the denture base resin, which tends to occur due to the presence of deleterious combination of oxidation and strong alkaline solution present in the sodium perborate type of denture cleanser.

The probable cause of color change observed after immersion in the denture cleanser was that these contain

sodium perborate which forms an alkaline peroxide solution of pH ranging from 9 to 11. Nikawa et al.[19] stated that reason of damage to denture resin when immersed in peroxide-containing denture cleanser was increased the peroxide content and the accelerated level of oxygenation in highly alkaline solution. They have effervescent component such as sodium perborate or sodium bicarbonate, which when dissolved in water form alkaline peroxide solution that decomposes to produce oxygen that loosens the food debris via mechanical means. Therefore, its results in hydrolysis and decomposition of polymerized acrylic resin itself. This is the reason why the sodium perborate denture cleanser exhibits greater influence on color stability in comparison to any other type of denture cleansers.

Therefore, care must be taken to not expose the denture resin to the peroxide-type denture cleanser for a longer period of time and should instruct the patient to follow the instructions properly.

To increase the adherence of food debris and microorganisms, surface roughness plays a important role as it accelerates the biofilm formation by providing retentive areas and makes it difficult to remove the biofilm from the denture surface. Surface roughness was estimated by value of Ra, which gives the average of peaks and depressions on the surface and enables us to evaluate the possibility of bacterial adhesion.

In this study acrylic resin group exhibited change in surface roughness which was seen maximum with Clinsodent. Surface roughness of acrylic resin with Clinsodent and Secure was camparable. Fittydent showed least change in surface roughness in camparison with control group. Similar result pattern was observed in lucitone- polyamide group.

Quirynen and Bollen[20] also emphasized on importance of having the smooth denture surface because having rough surfaces attracts bacteria, which will adhere to these surfaces for a long period of time making them difficult to be removed by regular hygiene methods. Therefore, recommended surface roughness should be ≤2 μm. Williams and Lewis[21] also supported the fact. The literature also states use of the smooth acrylic surface having roughness of 0.12 μm, which is well below the critical value of 2 μm.

These rough surfaces can be avoided by proper finishing of dentures, which involves both abrading and polishing. Finishing abrasives advocates, the use of hard and coarse abrasives to remove gross irregularities from the surface, whereas polishing abrasives advocates the use of finer particle sizes to smoothen the surfaces that had been roughened by finishing abrasives.

Peracini et al. on the other hand stated that the sodium perborate type of denture cleanser did not alter the surface roughness of acrylic resin. Therefore, it was concluded that while using alkaline peroxides, the time of immersion along with the type of denture base resin used was considered important[22.]

In this study eighty samples of acrylic resin and eighty samples of Lucitone- polyamide were prepared to examine and compare the effect of three commercially available denture cleanser on acrylic resin and Lucitone-polyamide. All samples were subjected to testing after 90 days of immersion in the respective groups of denture cleansers. Color stability, surface roughness, and flexural strength were checked after the immersion period.

ANNOVA and POST HOC TEST showed the result to be satisficing when three commercially available denture cleanser were taken into consideration. It was concluded that acrylic resin samples when immersed in Secure denture cleanser showed maximum change in flexural strength, followed by Clinsodent. The least change in flexural strength was seen in the samples immersed in

Fittydent in camparison to the control group. Similarly Lucitone-polyamide group exhibited change in flexural strength, which was maximum with Secure denture cleanser, followed by Clinsodent and Fittydent. In both the groups Fittydent denture cleanser exhibited least change in flexural strength making it ideal to use by the patient in camparison to Clinsodent and secure.

Hence within the limitation of the study, Fittydent denture cleanser showed least change in flexural strength in camparison to Secure and Clinsodent.

Acrylic resin group exhibited change in surface roughness which was seen maximum with Clinsodent. Surface roughness of acrylic resin with Clinsodent and Secure was camparable. Fittydent showed least change in surface roughness in camparison with control group. Similar result pattern was observed in luciton- polyamide group. Therefore Fittydent denture cleanser caused least damage to both the groups making it good to use in camparison to Secure and Clinsodent.

In this study secure and Clinsodent showed less color change in camparison to Fittydent in both groups.

The reliability of denture cleanser is also dependent upon a patient's capability to effectively use it.

Limitation of the study:

1. Only chemical solutions were studied, mechanical and ultrasonic techniques could also have been compared.
2. There was only two type of denture-based resin used and the parameters like pH of saliva were not simulated as that of normal saliva.
3. The study did not simulate clinical behaviors as it was conducted at room temperature. To overcome this limitation, the in vivo study should be conducted in future along with exploring other mechanical properties.

Summary and Conclusion

Maintaining a good oral hygiene is a pre-requisite to overall good health and wellbeing of an individual. With older age, poor motor and sensory reflexes maintaining good hygiene becomes a challenge for denture wearers. Poor hygiene can be related to plaque formation, staining of dentures, bad odor, bad taste, poor aesthetics, accumulation of microorganisms causing mucosal irritation etc. The dentures of even healthy individuals must be considered as possible sources of pathogenic microorganisms. There are several oral hygiene techniques and products available to clean dentures. With all manufacturer's claiming their material to be of highest efficiency a prosthodontist is not able to recommend a single denture cleanser with complete confidence. So, the present in vitro study was conducted to compare the effect of commercially available denture cleansers namely Clinsodent, Secure and Fittydent on acrylic resin and Lucitone-polyamide with distilled water as control for denture cleansers.

Within the limitations of present study, it was concluded that:

1. Fittydent exhibited the maximum color change in camparison to Secure and Clinsodent in both the groups.
2. Fittydent causes least surface roughness in camparion to Secure and Clinsodent in both the groups.
3. Fittydent causes least change in flexural strength in camparison to Clinsodent and Secure.
4. Immediate cleansing of dentures with running tap water after meal is strongly recommended.

Furthermore, Scope of the study

Further investigation with a bigger sample size and range of denture cleansing techniques and materials are suggested

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Legend Figures

Figure 1: Materials used in the study

Figure 2: Denture cleansers

Figure 3: Stainless steel mold

Figure 4: Armamentarium

Figure 5: Hydraulic Press

Figure 6: Elico SP 150 UV Visible Spectrophotometer

Figure 7: Wax Bath (left) and Vibrator (right)

Figure 8: Acrylizer (left) and Stop Watch (right)

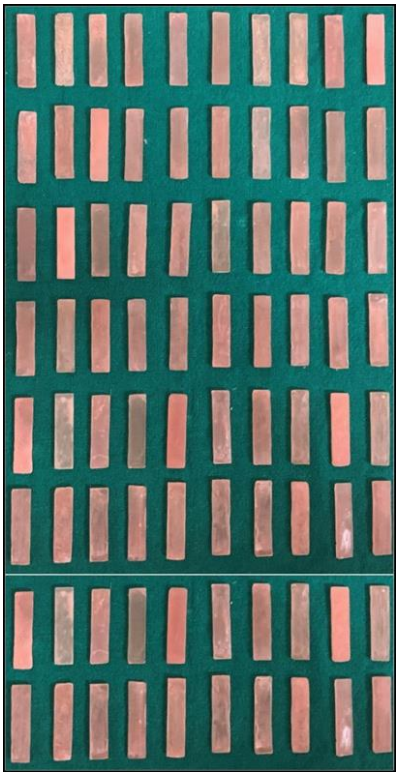

Figure 9: Group 1- 80 samples of conventional poly (methyl methacrylate) heat cured denture base resin.

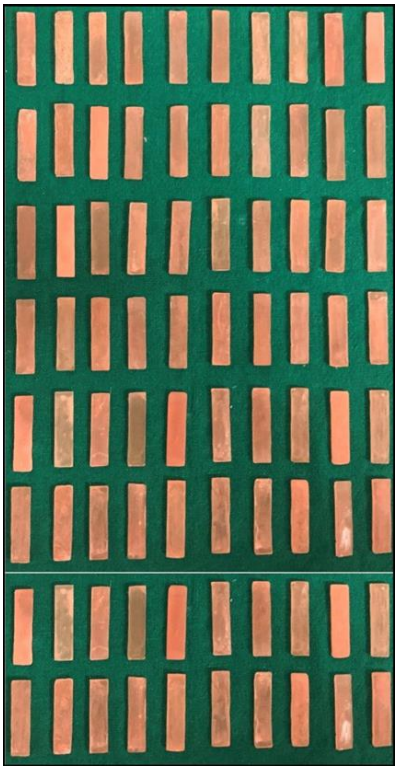

Figure 10: Group 2- 80 samples of Lucitone- polyamide denture resin.

Figure 11.1: Preparation of Distilled water as Denture Cleanser

Figure 11.2: Preparation of Fittydent Denture Cleanser

Figure 11.3: Preparation of Secure Denture Cleanser

Figure 11.4: Preparation of Clinsodent Denture Cleanser

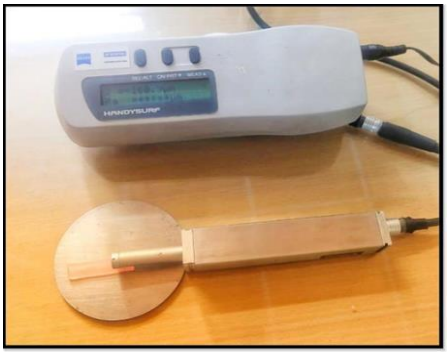

Figure 12: Surface Roughness Tester -Handysurf E 35 B

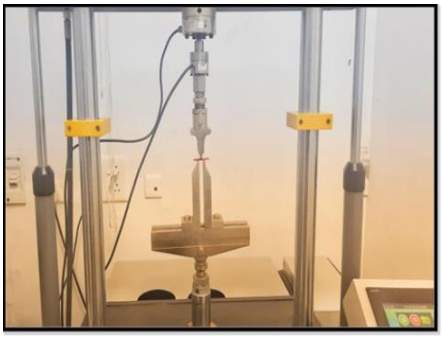

Figure 13: Tinius Oslen Universal Testing Machine

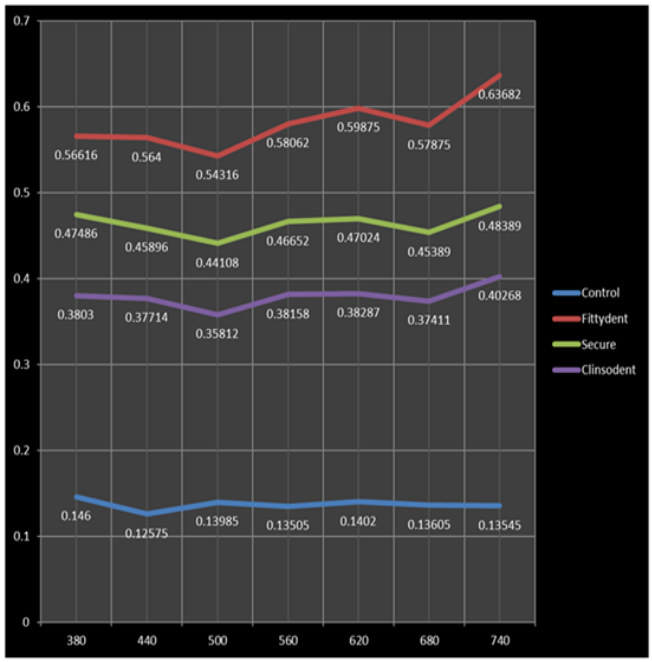

Figure 14: Reflectance value of different materials at different wavelengths in group 1

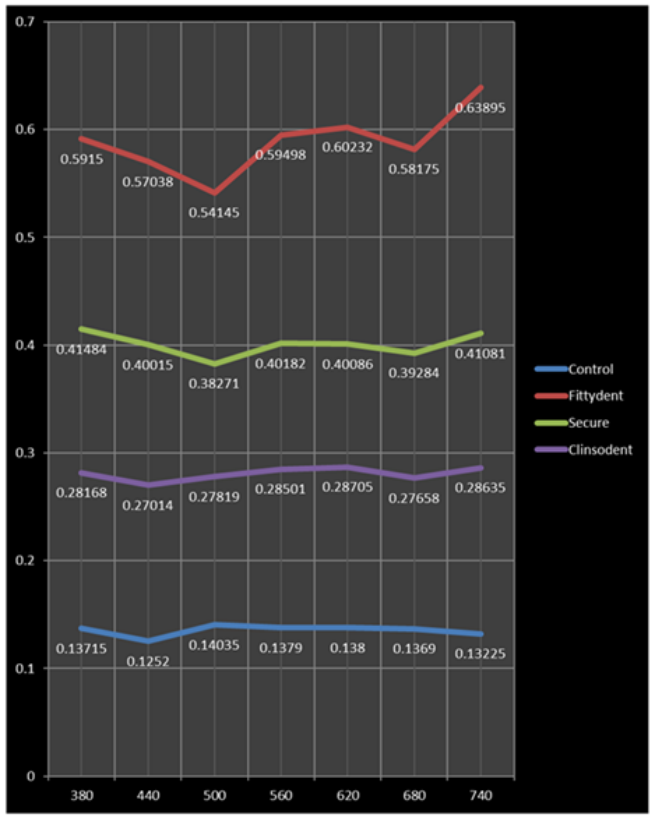

Figure 15: Reflectance values of different materials at different wavelengths in group 2

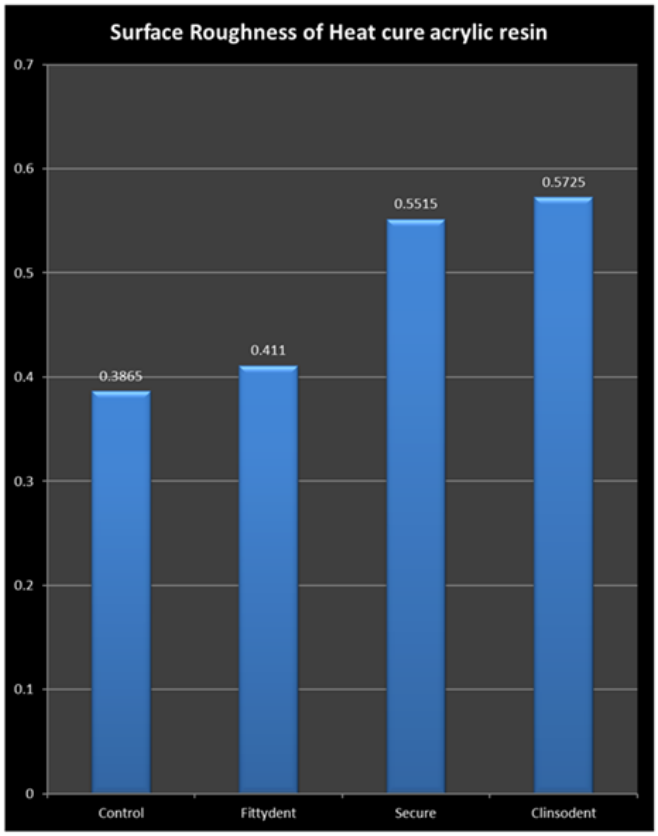

Figure 16: Compares surface roughness of heat cure acrylic resin from 0 to 0.7 after immersion in control and 3 commercially available denture cleanser

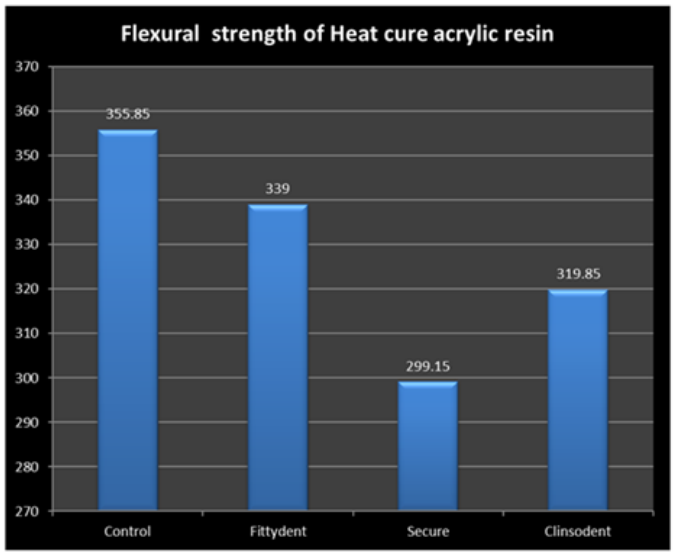

Figure 17: Compares Flexural strength of heat cure acrylic resin from 270 to 370 after immersion in control and 3 commercially available denture cleanser.

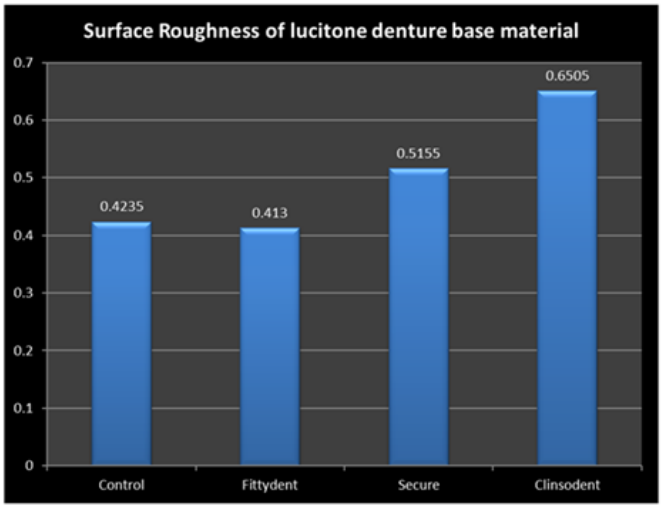

Figure 18: Compares surface roughness of Lucitone denture base material from 0 to 0.7 after immersion in control and 3 commercially available denture cleanser

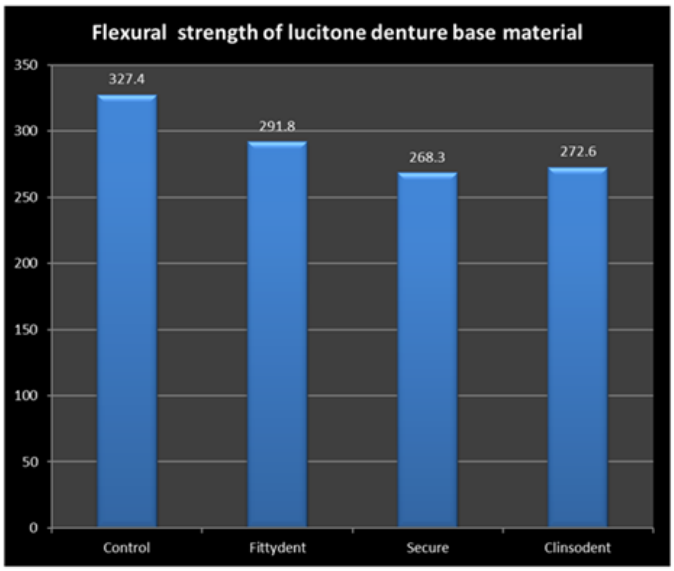

Figure 19: Compares Flexural strength of Lucitone denture base material from 0 to 350 after immersion in control and 3 commercially available denture cleanser