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The Effect of Silicone Soft Denture Liner Immersion in Alkaline Peroxide and Sodium Hypochlorite cleanser on Hardness and Surface Roughness

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Abstract

Soft denture liner applied in the intaglio surface of a denture base which directly touches the problematic ridge or mucosa, functioning as a cushion for a cushioning effect, absorbing pressure and distributes balanced and equal pressure to the tissue under it, helps with denture retention and as a conditioner on tissues that experience trauma. SDL usage for a long term period can cause a lot of problems like its soft properties, bonding failure between SDL and denture basis, formation of porosity, discoloration, solubility and microorganism colonialization. The change of physical and mechanical properties of SDL materials can be caused by daily denture cleaning with immersion in chemical cleanser liquid like alkaline peroxide and sodium hypochlorite 0,5%. This study aims to observe the effects of immersion in alkaline peroxide and sodium hypochlorite 0,5% to self-cured and heat-cured silicone SDL surface hardness and roughness. 24 self-cure silicone SDL (mollosil) and heat-cured (Molloplast B) samples made by a custom made metal mould with a 15 mm diameter and 10 mm height. Hardness measurement samples (n=12) and surface roughness samples (n=12). The samples are divided into 3 groups (n=4) and pre-immersed in Bi distilled water for 24 hours, stored in incubator at 37^0 C temperature as a simulation of the oral cavity. The grouped samples are then immersed in alkalineperoxide, sodium hypochlorite 0,5% liquid cleansers, and Bi distilled water as a negative control for an estimated time of 1 year. Surface hardness is measured using Shore A Durometer, SHU (shore hardness unit) and surface roughness is measured using Atomic Force Microscope (AFM) in micrometers (μm). Data analysis results by ANOVA shows that the effects of immersing self-cured and heat-cured silicone SDL on the three liquid cleaners; Bi distilled water, alkaline peroxide, and sodium hypochlorite 0,5% to hardness and surface roughness is insignificant. The result of this study concludes that self-cured and heat-cured silicone SDL immersion on alkaline peroxide, and sodium hypochlorite 0,5% is safe to use as denture cleansing method because it will not alter physical and mechanical properties on both types of soft denture liners.

Keyword: Hardness, surface roughness, self-cured silicone soft denture liner, heat-cured silicone soft denture liner, alkaline peroxide, sodium hypochlorite 0,5%

Introduction

Soft Denture Liner (SDL) or resilient denture liner is a temporary or definitive liner on full denture intaglio surface, partial dentures and intraoral maxillofacial dentures functioning as a cushioning effect, distributing functional pressure equally on the mucosa of denture supporting tissue,

preventing locally focused pressure and increasing retention and stabilization of dentures. Soft denture liners are indicated on patients with severe cases of ridge resorption, knife edge ridges, thin and non-resilient mucosa, severe bone undercuts, congenital or acquired palatal defects, immediate dentures, as a relining post implant installation, full dentures that contacts with teeth, bruxism, and xerostomia.

Soft denture liners are classified by period of use, compositions, and it's activation process. Based on the period of use, there are short term (tissue conditioners) and long term SDL. Based on the material compositions, long term SDL consists of plasticized acrylic resin, silicone rubber, plasticized vinyl polymers and copolymers, hydrophilic polymers, polyphosphazine fluoropolymers, fluoroethylene and polyvinyl siloxane addition silicones. Based on its activation technique there are chemically activated atau room temperature vulcanizing (RTV) (self-cured) and heat activated or heat temperature vulcanizing (HTV) (Heat-cured). As a material for dentistry these soft denture liner properties are essential: biocompatible, non-irritant on tissues and free from *candida albicans* and other microorganisms, high level of adhesion, hardness, surface roughness, dimension stability, color stability, minimal water sorption and material solubility when immersed in water or denture cleansers. Long term SDL wear either in the oral cavity or when immersed in denture cleansers can cause a lot of problems like bond failure between SDL and denture base, loss of softness (increase in hardness), porosity, discoloration, material dissolving in saliva or denture cleansers and formation of microorganism colonialization. Change in surface roughness of SDL material caused by long term wear can be worse by inadequate denture hygiene, which will cause oral candidiasis. This is why denture wearers has to maintain their denture hygiene and do a routine denture cleaning to eliminate and prevent colonialization and infection of microorganisms especially candida albicans. Denture cleaning which aims to remove plaques, stain, and biofilm layer can be done by various methods, mechanical, chemical, and a combination of chemical and mechanical. Mechanical method are not recommended in cleaning SDL materials because it might temper the resilient properties and cause surface roughness. Chemical cleansing is a preferred method, especially for elder patients, and patients with physical limitation because it is done by immersing denture in cleansing solutions. Inadequate denture cleaning can contribute in impairing physical and mechanical properties of SDL materials. Based on its composition, chemical cleansers consists of alkaline peroxide, hypochlorite, acid, disinfectant, and enzymes. Alkaline peroxide is a cleaning material that is most used and available in powder of soluble tablets. A few study has been done to test the effects of immersion in liquid denture cleansers on hardness of silicone SDL. Pahuja et al, 2013 has studied that the hardness of self-cured silicone SDL immersed in sodium hypochlorite 0,5% liquid for an interval of 1 week, 1 month, 3 months, and 6 months are insignificant. Narwal, 2015 found that the surface roughness on self cured silicone SDL increased after 6 months of immersion in sodium hypochlorite. Mohammed et al, 2016 observed that the increase in hardness of self-cured silicone SDL immersed in alkaline peroxide is significant in the 7^{th}, 30^{th}, and 90^{th} day. Tan H et al, 2000 shows that the decrease in hardness of heat-cured silicone SDL immersed in various cleanser liquid where the surface is prepared with different roughness. Lower hardness is a properties that is preferred in SDL material but other factors (e.g. adhesion of base and tear strength) should also be considered when choosing SDL.

Denture cleaning by immersion in cleanser liquid also affects surface roughness. Oxygenation in

strong alkaline and high ion concentration (sodium and potassium) can be a factor that could cause porosity in SDL surface. Surface roughness of SDL can also be linked to porosity occurred during material mixing where air bubbles are trapped. Vieira et al, 2010 compared the effectivity of peroxide and sodium hypochlorite 0,5% cleansers towards surface roughness and found that sodium hypochlorite 0,5% causes the highest surface roughness although insignificant. A study by Mese A, 2008 shows the highest roughness value on self-cured silicone SDL after 24 hours and 6 months immersion on alkaline peroxide. Jin et al (2003) also found that there were changes in surface roughness and color stability of silicone soft denture liner after immersing it in cleanser liquid as a routine in maintaining denture hygiene that would affect material properties of SDL, which is why dentists should choose cleanser liquid that are most accurate for each SDL. This study is aimed to observe the effects of immersing silicone SDL in alkaline peroxide and sodium hypochlorite 0,5% cleansers towards its hardness and surface roughness.

MATERIAL AND METHOD

Samples in this study uses two long term SDL materials which are self-cured silicone SDL (mollosil) and heat-cured silicone SDL (Molloplast B) which are 24 in total. Samples are made using a cylindrical metal mold with a diameter of 15mm and thickness of 10mm based on ASTM: D-2240-64T.

Self-cured silicone SDL sample fabrication:

12 samples of 15 mm diameter and 10 mm thickness self-cured silicone SDL. Silicone spray were applied on the metal mould surface and its cover for an easy release. Self-cured silicone SDL material is mixed on a glass slab with a spatula for 30 seconds, base: catalyst ratio of= 1:1 based on manufacturer instructions, it is then applied to the mold. Mold is covered with a metal cover and tightened with screws and are pressed with a standard cuvette press for 30 minutes. After the curing is done, self-cured silicone SDL is taken out from the mold and prepared with a sharp blade.

Heat-cured silicone SDL sample fabrication:

12 samples of heat-cured silicone SDL are made with 15 mm diameter and 10 mm thickness. Silicone spray are applied on metal mould surface and the cover for easier release. Metal mould are placed on top of the metal lower cover. Heat cured silicone SDL material are applied inside the mould. Filling is done with pressing the materials in the hole using fingers, the material is filled until it reaches the model surface and is covered and tightened with a screw. The upper metal cover is then placed on the top of the mold filled with SDL material and is screw tight and pressed with a standard pressing device for 15 minutes. The mould that is filled with heat-cured silicone SDL material is immersed in a water bath for 2 hours in 100^0 C for it to polymerize, the metal mould is then left to cool in room temperature. After polymerization is finished, the heat cured silicone SDL sample is taken out of the old and tidied up with a sharp blade.

Sample immersion:

1. All samples are immersed in Bi distilled water and stored in an incubator of $37^0 \pm 2^0$ C for 24

hours as a simulation of oral cavity.

2. Samples are divided into 3 groups which are samples immersed in Bi distilled water (Group A : Control); in alkaline peroxide cleanser liquid (Group B); in sodium hypochlorite 0,5% (group C).
3. The samples are immersed for 1 year (91,25 hours) in room temperature
4. Each groups of samples is taken out and let dry to test its hardness and surface roughness.

Hardness and roughness measurement

The hardness is tested using Shore A Durometer in Shore Hardness Unit. Surface roughness in each group is done by Atomic Force Microscope (AFM) Nanosurf easyScan2 in micrometers (μm).

Data analysis

Univariate analysis to find out mean and standard deviation (SD) value of hardness and surface roughness of self-cured silicone SDL material and heat-cured silicone SDL immersed in each liquid cleansers. ANOVA test is used to figure out the effects of self-cured and heat -cured silicone SDL in each cleansers.

Results

Table 1 shows that mean and SD roughness on self-cured and heat-cured silicone SDL group samples immersed in Bi distilled water as control and in alkaline peroxide and sodium hypochlorite 0,5% cleansers. In table 2, ANOVA test results shows that the effects of self-cured silicone SDL in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% on hardness is insignificant (p=0,633) and test results on heat- cured silicone SDL shows that its immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% on hardness is insignificant (p=0,144).

Table 1. Hardness mean of Soft Denture Lining immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5%

No	Hardness (Shore Hardness Unit /SHU)					
	Self- Cured silicone SDL			Heat Cured silicone SDL		
	Bi distilled water (Control)	Alkaline Peroxide	Sodium Hypochlorite 0,5 %	Bi distilled water (Control)	Alkaline Peroxide	Sodium Hypochlorite 0,5 %
1	24,83**	24,83**	24*	41,36*	41,16	41
2	24,66	24,33	24,5	41,5	40,5*	41,16
3	24,66	24,03*	24,83	42,23**	41,46	41,33**
4	24,36 *	24,5	25,53**	41,83	41,86**	41*

X ± SD	24,63±0,19	24,42 ±0,33*	24,71±0,64**	41,73 ±0,38**	41,25±0,57	41,12±0,15*

Explanation : * lowest value ** Highest Value

Table 2. ANOVA test results on Effects of self-cured and heat cured Silicone Soft Denture Liner immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% on Hardness Value.

Cleanser Types	**n**	**Hardness (SHU)**			
		Self- Cured silicone SDL	p	Heat Cured silicone SDL	p
Bi distilled water (Control)	4	24,63± 0,19	0,633	41,73 ± 0,38	0,292
Alkaline Peroxide	4	24,42± 0,33		41,25 ± 0,57	
Sodium Hypochlorite 0,5%	4	24,71 ± 0,64		41,12± 0,15	

Table 3, shows mean and SD value of surface roughness on self-cured and heat- cured silicone. SDL surface roughness immersed in Bi distilled water as control and in alkaline peroxide and sodium hypochlorite 0,5% cleansers. In table 4, ANOVA test results shows that the effect of self-cured silicone SDL immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% on surface hardness is insignificant (p=0,732) and test results on heat- cured silicone *SDL* samples shows that the effect of immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% does not alter hardness value significantly (p=0,203).

Table 3. Surface roughness mean of Soft Denture Lining immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5%

Sample no	Surface Roughness (µm)					
	Self- Cured silicone SDL			**Heat Cured silicone SDL**		
	Bi distilled water (Control)	Alkaline Peroxide	Bi distilled water (Control)	Alkaline Peroxide	Bi distilled water (Control)	Alkaline Peroxide
1	0,08*	0,13**	0,15**	0,15**	0,06*	0,14
2	0,15**	0,12	0,12	0,10*	0,08	0,13*
3	0,11	0,08*	0,12	0,10*	0,11	0,13*
4	0,12	0,12	0,11*	0,12	0,15**	0,17**

X ± ± SD	0,11 ± 0,02*	0,11± 0,02*	0,12± 0,01**	0,12 ± 0,03	0,10± 0,03*	0,14± 0,01**

Explanation : * lowest value ** Highest Value

Table 4. ANOVA test results on Effects of self-cured and heat-cured Silicone Soft Denture Liner immersion in alkaline peroxide and sodium hypochlorite 0,5% on surface Roughness Value.

Cleanser Types	n	Surface Roughness (µm)			
		Self- Cured silicone SDL	p	Heat Cured silicone SDL	p
Bi distilled water (Kontrol)	4	0,11±0,02	0,732	0,12 ±0,03	0,203
Alkaline Peroxide	4	0,11±0,02		0,10 ± 0,03	
Sodium hypochlorite 0,5%	4	0,12 ± 0,01		0,14 ±0,01	

DISCUSSION

The study results shows that the mean hardness of all self-cured and heat -cured silicone SDL corresponds to the ISO 10139-2:2016 standard that classifies soft denture lining material into two types; soft and extra soft. Shore A Hardness value criteria after 24 hours immersion in distilled water in 37^{o}C for soft type is 25-50 SHU and 25 SHU for extra soft type. Here, both types of silicone SDL are soft types SDL.

Study results shows that surface roughness of self-cured and heat -cured silicone SDL immersed in each cleanser liquid; Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% for 1 year is still in clinically acceptable limits, which is smaller than 0,2 µm, in line with study results evaluating surface roughness with the same liquid but in acrylic based. Study results Zortuk M et al, 2008 states that surface roughness of 0,3 µm can be felt by patient tongue and its negative effect could interfere patients comfort. Dentistry material with rough surfaces can facilitate microorganism attachment and complicate its natural cleanser even with other cleansing method.

ANOVA result test shows there are no effects of immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% to hardness of self-cured silicone SDL valued p= 0,633 (p>0,05) and of heat cured silicone SDL valued p=0,144 (p>0,05). There are alteration in hardness properties on SDL affected by various factors, duration of immersion, pH and environment temperature, type of liquid,

concentrate and composition of cleanser. This study is uses 1 year methodology of immersion which is generally the wear duration of SDL, but heat cured silicone SDL material has a longer wear duration, which is 3-6 years. Insignificant effects on self-cured and heat cured silicone SDL can be caused by inadequate immersion time. Other than that silicone SDL has hydrophobic properties which makes it more challenging to clean with water or denture cleanser. The water absorption capability is low which is 0,30% in distilled water, where its stability dimension becomes larger, has better elasticity, good color stability and longer durability.

This study uses alkaline peroxide (polident, *GlaxoSmithKline, Brentford, united kingdom*) tablet diluted in 200 ml Bi distilled water and 0,5% sodium hypochlorite. Alkaline perioxide and sodium hypochlorite chemical cleanser liquid is alkali group cleansers with different chemical compositions. Alkaline peroxide is generally used because it is more affordable, is easily available and is biocompatible in the oral cavity. These tablets contains effervescent which gives mechanical and chemical actions, the mechanical action is caused by bubbles that are formed when oxygen is released in the reaction. On prior studies it is found that these bubbles can affect mechanical properties of denture materials. There are no significant effects on hardness caused by alkaline peroxide concentrations, the tablet only contains a small amount and is not pure alkaline peroxide liquid. This study shows the same results as a study by Olivieira et al, 2006 where alkaline peroxide and sodium hypochlorite 0,5% doesn't have any effect on the hardness of heat cured silicone SDL material (Molloplast B) but does affect self-cured silicone SDL hardness. Sodium hypochlorite cleansers is an oxidizing and hydrolysis substance, it is a strong alkali with a pH higher than 11, hypertonic and has low viscosity, has bactericidal and proteolytic properties. Conventionally sodium hypochlorite is produced through chlorine gas effervescence via sodium hydroxide liquid (NaOH) to produce sodium hypochlorite (NaOCl), salt (NaCl) and water (H_2O). The liquid will experience concentration reduction with time and is affected by temperature and exposure to light. The cleanser concentration decreasing while immersion causes insignificant changes in hardness and surface roughness of self-cured and heat- cured silicone SDL materials.

Analysis with ANOVA test shows that there are no effects of immersion in Bi distilled water, alkaline peroxide and sodium hypochlorite 0,5% on surface roughness of self-cured silicone SDL with a value of p= 0,732 (p>0,05) and on heat-cured silicone SDL with p=0,203(p>0,05). Factors that are considered affecting the surface roughness like types of cleansers, chemical composition of cleansers, pH and temperature of liquid, porosity formed on the mixing process of SDL materials. Surface roughness is an essential property of SDL when considering biofilm formatioin and *Candida albicans* colonialization. Although chemical cleansing has been considered as en effective method to prevent *Candida albicans* invasion and plaque formation on dentures, some types of denture cleansers are reported to alter SDL in a short period of time which is why denture cleanser material used for plaque control should be able to decrease microorganism contamination and has minimal effect on SDL material physical properties.

Each chemical cleanser liquid has different mechanism on self-cured or heat cured silicone SDL surface which will effect penetration and absorption of silicone surface. Before study shows that oxygenation on strong alkali liquids is a damaging factor and peroxide contents is one of the factors that might be damaging more that the other components. Peracini, 2016 explained that sodium hypochlorite

0,5% is more effective on preventing biofilm formation by pathogen on dentures, but is less sensitive on roughness, while alkaline peroxide has a role of preventing pathogen interactions by making denture surfaces smoother to prevent biofilm forming and will maintain the integrity of dentures when adapting to oral cavity environment.

In this study the effect of immersion in chemical cleansers like alkaline peroxide and sodium hypochlorite 0,5% on roughness of self-cured and heat-cured silicone SDL does not show a significant result so that both chemical cleansers can be used in denture routine procedure especially on acrylic bases combined with silicone SDL materials. Bases that are made from metal frames and silicone SDL is recommended to use alkaline peroxide cleansers which will not be corrosive on metal. Sodium hypochlorite is not recommended because it might add surface roughness and corrosion in metal denture materials.

Conclusion

Based on this study's result the effect of SDL silicone immersion on alkaline peroxide and sodium hypochlorite 0,5% toward hardness and surface roughness of self-cured and heat cured silicone SDL is insignificant, it is concluded that clinical implications of chemical cleansing by immersing dentures in alkaline peroxide and sodium hypochlorite 0,5% denture cleansers can be used as it doesn't alter physical and mechanical properties of self-cured and heat cured silicone SDL materials on bases made of acrylic and silicone SDL.

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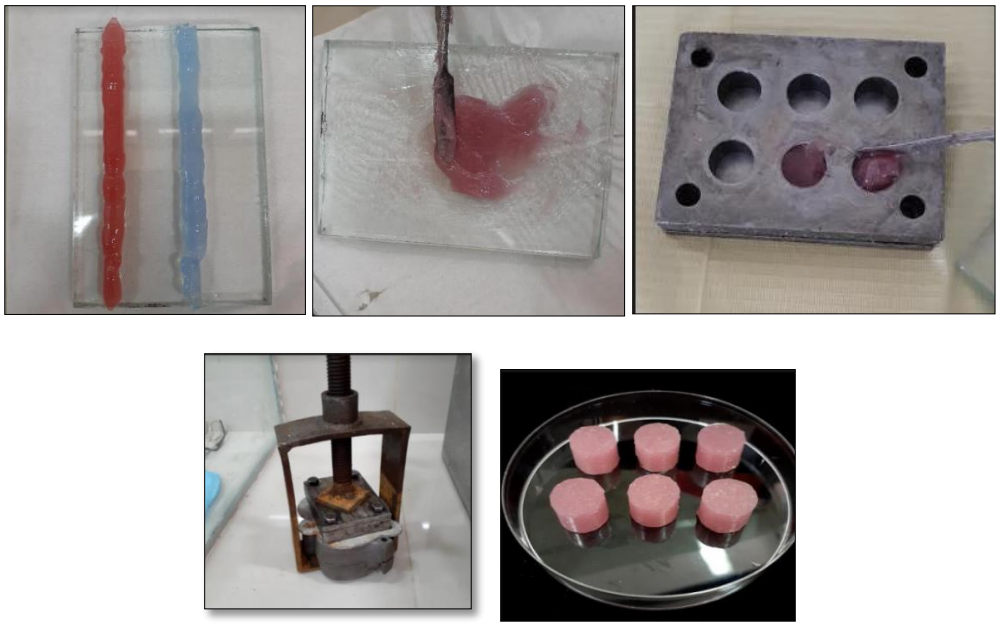
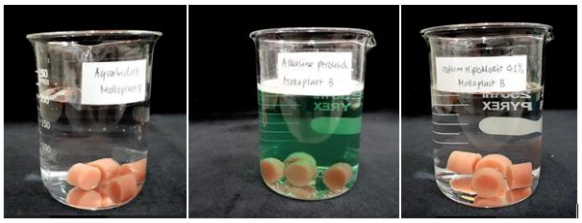


Picture 1. Making of self-cured silicone soft denture liner samples

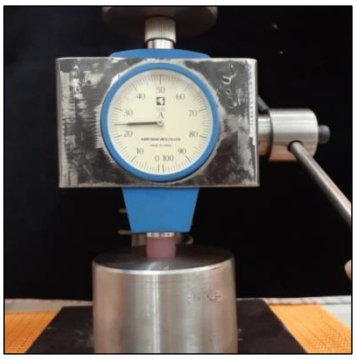
Picture 2. Making of heat-cured silicone soft denture liner samples



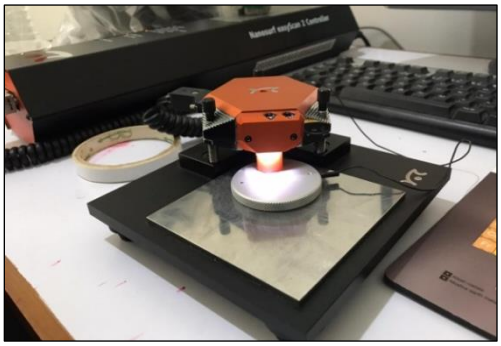
Picture 3. Mollosil immersed in a solution of (A) Bi distilled water ; (B) Alkaline peroxide ; (C) Sodium hypochlorite 0.5%

Picture 4. MolloPlast B immersed in a solution of (A) Bi distilled water ; (B) Alkaline peroxide ; (C) Sodium hypochlorite 0.5%

Picture 5. Siliconesoft denture liner samples ready for hardess and surface roughness testing

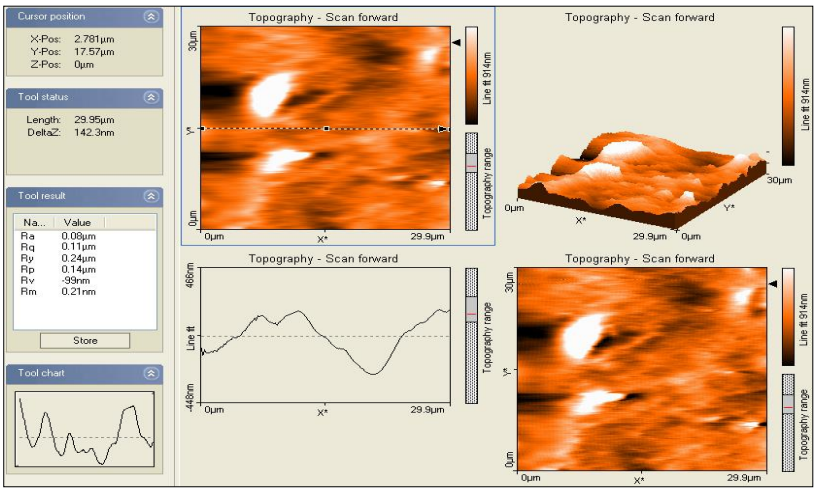


Picture 6. Siliconesoft denture liner hardness measurement using Shore A Durometer

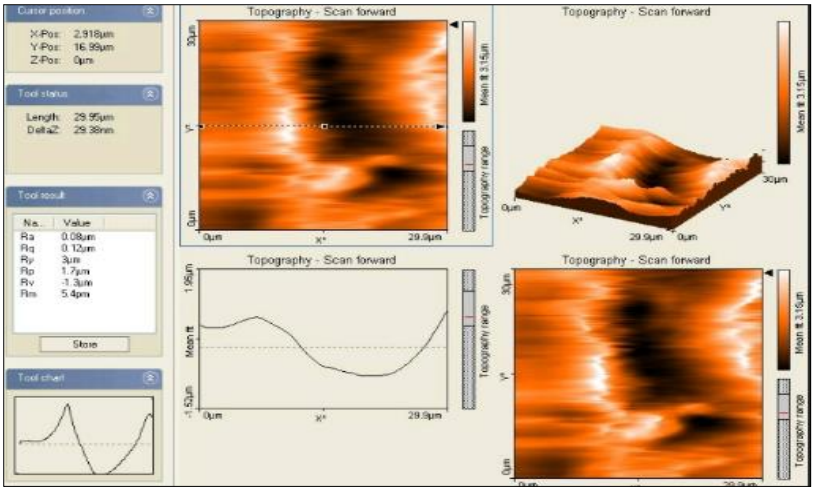


Picture 7. Siliconesoft denture liner surface roughness measurement using Atomic Force Microscope Nanosurf Easyscan2

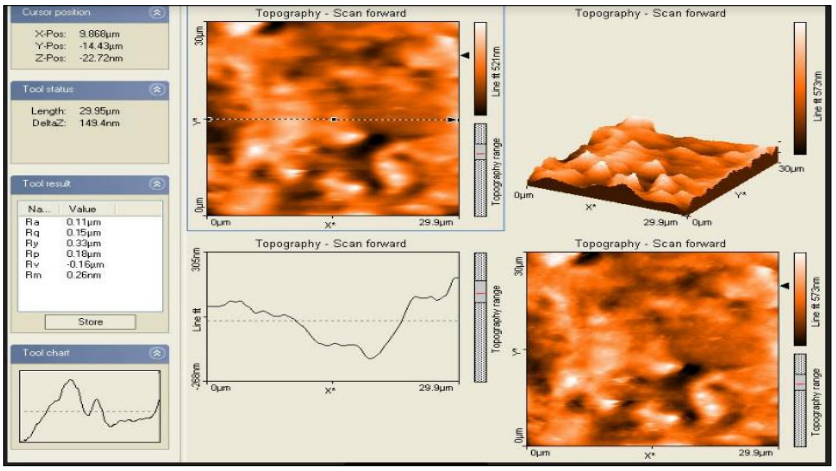
Topography image samples of self-cured and heat cured silicone Soft denture liner surface roughness



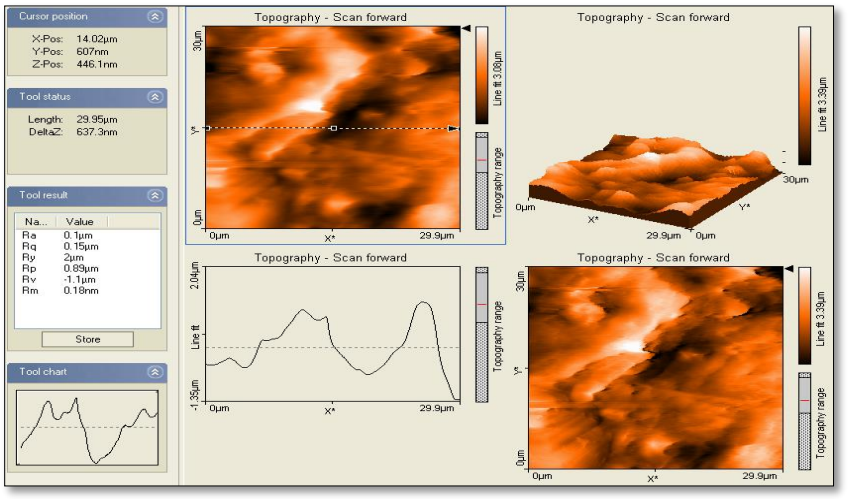
Picture 8. Topographyofsurfaceroughness ofself-cured soft denture liner silicone immersed in Bi distilled water



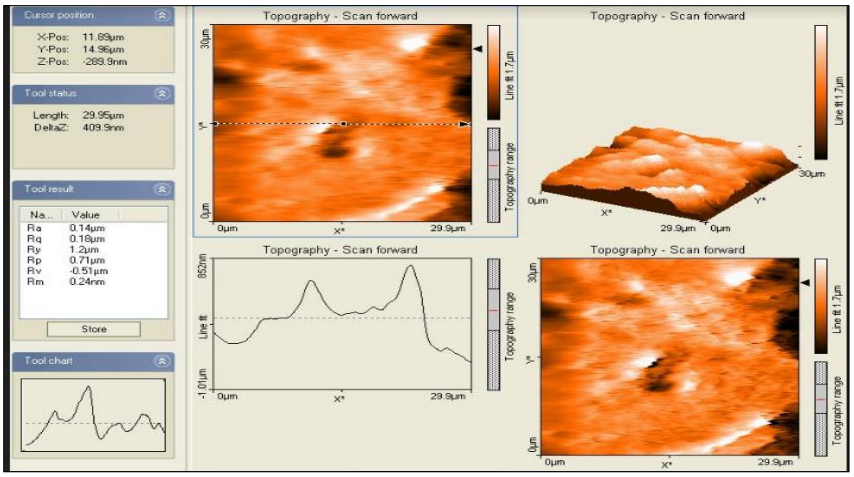
Picture 9. Topographyofsurfaceroughness ofself-cured soft denture liner silicone immersed in alkaline peroxide



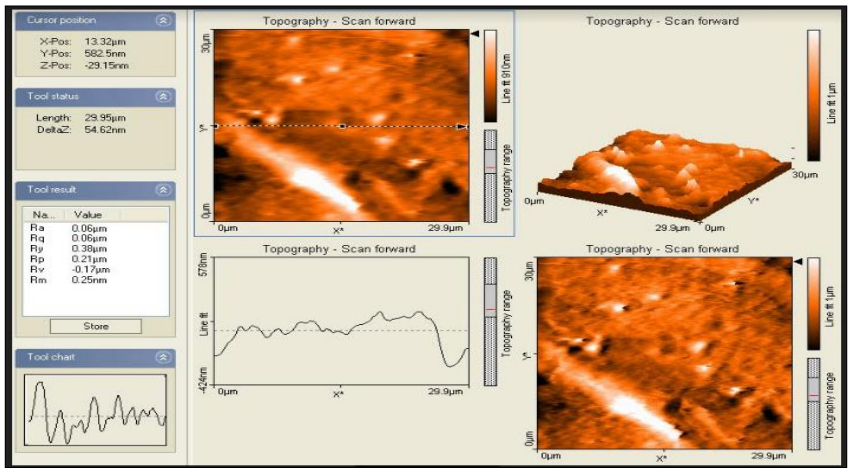
Picture 10. Topographyofsurfaceroughness ofself-cured soft denture liner silicone immersed in sodium hypochlorite 0,5%



Picture 11. Topographyofsurfaceroughness ofheat-cured soft denture liner silicone immersed in Bi distilled water



Picture 12. Topographyofsurfaceroughness ofheat-cured soft denture liner silicone immersed in alkaline peroxide



Picture 13. Topographyofsurfaceroughness ofheat-cured soft denture liner silicone immersed in sodium hypochlorite 0,5%