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ORIGINAL ARTICLE

Evaluation and comparison of the effect of denture cleansers on tensile strength of silicone based resilient liner attached to heat cured denture base material – An *in vitro* study

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ABSTRACT:

Purpose: To evaluate the tensile bond strength of silicone-based resilient liners attached to heat cured denture base material, when treated with different denture cleansing solutions. **Materials and Methods:** Sixty cylindrical liner specimens (30 UFi GEL P™ and 30 GC RELINE™ SOFT) were tested for tensile bond strength after immersing in various denture cleansers for a period of six months. Instron Universal testing machine was used for testing-the tensile bond strength. One way ANOVA and Mann- Whitney U tests were used for statistical analysis. **Results:** Tensile bond strength value of water and Fittydent increased over a period of six months, while Clinsodent showed a significant decrease in the Tensile bond strength value of UFi GEL P™.($p<0.05$). **Conclusion**: In the present study UFi GEL P^{TM} was observed as a better material when comparing with GC RELINE^{TM} SOFT with different variations in tensile bond strength when stored in denture cleanser over a period of 180 days.

Key words: Denture cleansers, tensile strength, silicone resilient liner.

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Introduction

Complete denture bases are fabricated commonly from rigid denture base materials like acrylic, vinyl and other resin polymers.[1] The fit of the denture base to the alveolar ridge progressively declines as the alveolar ridge resorbs, which affects denture stability, support and retention.[2] Relining is indicated to recapture the fit of the denture base, especially when the denture still retains proper vertical dimension, occlusal relationship and esthetics[3] and thereby eliminate the need for making new dentures.[4]

The ideal properties for a soft liner include resilience, tear resistance, visco elasticity, biocompatibility, lack of odor and taste, adhesive bond strength, low solubility in saliva, low adsorption in saliva, ease of adjustability, dimensional stability, color stability, lack of adverse effect on denture base material, resistance to abrasion, and ease of cleaning.[5] Two types of chair-side denture relining materials widely used in dentistry, includes hard and soft reliners. Hard relining materials are subdivided into several groups such as heat-cured, self-cured and light-cured. Soft or resilient reliners are preferred for sensitive mucosal tissues and are divided into the four groups based on their chemical structures like plasticized acrylic resins (chemical or heat cured), vinyl resins rubbers (polyurethane and polyphospazine type) and silicone rubbers.

Resilient denture lining material is as an elastic or viscoelastic material applied to the fitting surface of a denture. They act as a cushion for the denture bearing mucosa through absorption, dampening, and redistribution of forces transmitted to the stress-bearing areas of edentulous ridges, provide more equal force distribution, reduce localized pressure, and improve denture retention by engaging undercuts.[6] There are mainly two types of resilient liners used which include, silicone based and acrylic resins. Silicone based resilient liners include self-cure/room temperature vulcanizing (RTV) silicones and heat temperature vulcanizing (HTV) silicone (short-term or long-term).[7]

Water, hypochlorite solutions, alkaline peroxide solutions, acidic disinfectants solutions and enzymatic solutions are commonly used cleansing agents in clinical practice. Water sorption, bonding agents, processing

methods, chemistry of the material and changes in the bond strength in the harsh oral environment are important factors responsible for variation in hardness and tensile strength of silicone based soft denture liners.[8]

However, these soft liners exhibit multiple clinical failures characterized by loss of adhesion to denture base surface, poor tear strength and/or bulk deterioration, accumulation of debris and plaque, loss of resilience and fungal or microbial accumulation, bond failure. Many of these problems results from the increased water sorption and solubility when dentures are soaked in saliva during use or kept in water or aqueous disinfecting solution during storage.[7]

One of the most serious problems with these materials are bond failure between the resilient denture liner and denture base as the ability of the liner to effectively absorb and uniformly transmit the masticatory stresses is dependent on the integrity of the bond.[9] The purpose of this study is to evaluate and compare the effect of three commonly used denture cleansers on tensile bond strength of silicone based resilient liner attached to heat cure denture base material.

Materials and methods

Tensile Bond Strength Testing

This study contains 60 specimens of each liner (30 specimens of UFi GEL P™ and 30 specimens of GC RELINE™ SOFT). The liner filled in between cross sectional areas to assess the tensile bond strength. Universal testing machine was used for testing the tensile bond strength.

Preparation of Standardized Brass Mould

The acrylic blacks were prepared with dimension of 40 mm×10 mm× 10mm (L×W×H) by using a standardized brass mould. The brass mould contains 3 parts which was divided as upper, middle and lower parts. It was fitted and tightened by 4 screws on each corner of the mould. The middle part of the mould has a cavity space of 83 mm×10 mm× 10mm (L×W×H). A spacer slot was kept in the centre which divides the mould space into two equal spaces. The dimension of the slot is 3 mm×14 mm× 10mm. The equal space in the mould helps for processing two heat-cured acrylic blocks at the same time. Acrylization of PMMA blocks by using standardized brass mould is given in Figure 1.

Preparation of Poly Methyl Methacrylate (PMMA) Blocks

A standardized brass mould was used for preparation of 120 heat cured acrylic block specimens. Petroleum jelly was applied on the inner surface of the brass mould space for the easy removal of acrylic resin blocks. The acrylic resin mixed into a silicone acrylic jar by using a water powder ratio (3:1). It was filled into the mould space when the mix reached dough stage. The mould was kept under hydraulic press at a pressure of 2000 psi, an intermittent force was applied. And the mould was tightened by screws. After one hour of bench cure, the brass mould was immersed in the water bath in a Unident™ Acrylizer for short curing cycle followed for heat-cure denture base resin. 2 hours of curing at 74°C was done followed by 100°C for one hour. Then the mould was permitted to bench cool slowly from water bath temperature to room temperature. Then the brass mould was unsealed and polymerized acrylic blocks regained. The polishing of block surface is done by 240 Grit silicone Carbide paper. Remaining blocks are prepared by the same manner (Fig 2)

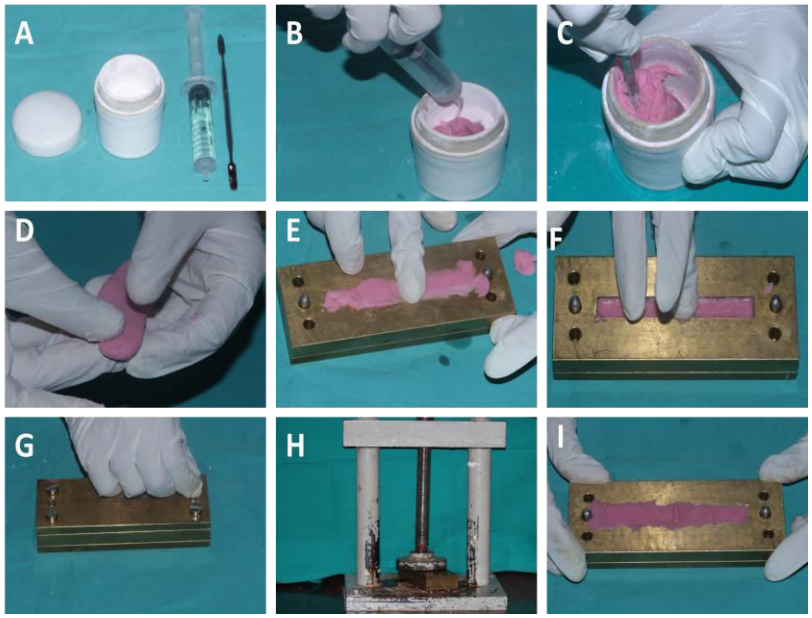

Figure 1: Acrylization of PMMA blocks by using Standardized Brass Mould A. PMMA monomer and polymer for mixing in acrylic jar. B and C. Mixing of heat cure polymer and monomer in acrlylic jar. D-F.Packing dough stage of heat cure acrylizing resin into brass mould.G.Tightening of screws of brass mould. H. Brass mould kept under hydraulic press I. Opening of brass mould after acrylization

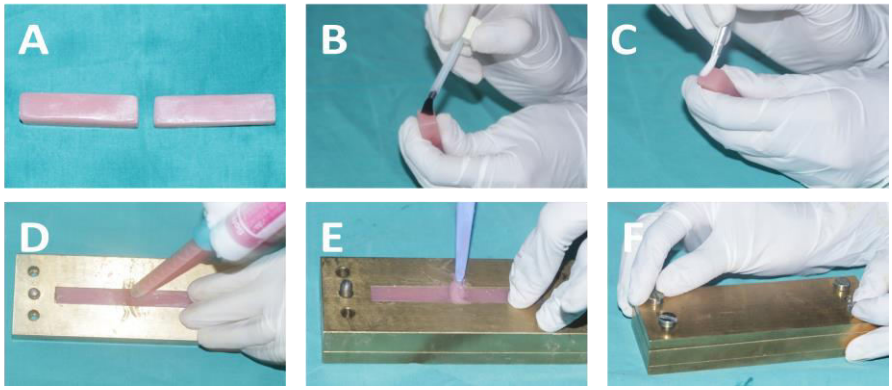

Figure 2: Preparation of Poly Methyl Methacrylate (PMMA) Blocks. A. Prepared PMMA Block. B. Applying UFi GEL P ™ Adhesive on PMMA Block Surface. C. Applying GC RELINE™ Primer on a PMMA Block Surface. D. Loading of GC RELINE™ SOFT LINER in between two acrylic blocks for Tensile. E. Loading of UFi GEL P™ liner between two acrylic block for Tensile Bond Strength. Strength. F. Tightening of screws after loading the Soft Liner into Brass Mould.

Preparation of Soft Liner Specimen

To prepare the soft liner specimen, the acrylic blocks were placed into the mould and the Brass spacer was removed. The area to be bonded was air dried for one minute. The prepared surface was then treated by adhesives and kept for 3 minutes. Soft liners were prepared by following manufactures instructions and then filled into the mould space between 2 acrylic blocks. Then the flask was covered by the upper part and tightened by screws. The mould was left for 10 minutes in room temperature. The specimen was removed after 10 minutes carefully then the excess part of the liner was removed by using a BP blade to get a final specimen with liner size of 3 mm× 10 mm × 10 mm between two acrylic blocks. Now the total dimension of the specimen was 83 mm× 10 mm× 10 mm. 60 samples were prepared by the same manner.

Designation and Distribution of Tensile Bond Strength Specimen

To determine the role of denture cleanser on tensile bond strength on long and short term storage, a total of 60 samples which was separated as 2 major groups based on two brands of liner material. Each group had 30 numbers of specimens. The first group considered as Group I (UFi GEL™ P) and second group considered as Group II (GC RELINE™ SOFT). Group I & II again separated as 3 subgroups (10 specimens in each group, 5 samples were subjected for evaluating tensile bond strength after one day and the other 5 samples were subjected after 180 days of storage.

GROUP I A¹: 5 samples of UFi GEL P™ were taken and kept in distilled water for period of 1 day.

GROUP I A²: 5 samples of UFi GEL P™ were taken and kept in distilled water for period of 180 days.

GROUP I B¹: 5 samples of UFi GEL P™ were selected and kept in Fittydent® Super cleansing denture cleanser solution for one day.

GROUP I B²: 5 samples of UFi GEL P™ were selected and kept in Fittydent® Super cleansing denture cleanser solution for a period of 180 days.

GROUP I C¹: 5 samples of UFi GEL P™ were selected and kept in Clinsodent® Powder denture cleanser solutions for one day.

GROUP I C²: 5 samples of UFi GEL P™ were selected and kept in Clinsodent® Powder denture cleanser for a period of 180 days.

GROUP II A¹:5 samples of GC RELINE™ SOFT were taken and kept in distilled water for period of 1 day.

GROUP II A²: GROUP I A² - 5 samples of GC RELINE™ SOFT taken and kept in distilled water for period of 180 days.

GROUP II B¹:5 samples of GC RELINE™ SOFT were selected and kept in Fittydent® Super cleansing denture cleanser solution for one day.

GROUP II B²:5 samples of GC RELINE™ SOFT were selected and kept in Fittydent® Super cleansing denture solution for a period of 180 days.

GROUP II C¹: 5 samples of GC RELINE™ SOFT were selected and kept in Clinsodent® powder denture cleanser solutions for one day

GROUP II C²: 5 samples of GC RELINE™ SOFT were selected and kept in Clinsodent® powder denture cleanser for a period of 180 days.

Evaluation of Tensile Bond Strength

For determining the tensile bond strength, Instron Universal testing machine was used (model no: 3365) and the imaging of tensile strength testing is given in Fig 3.The samples were placed vertically and firmly between the upper and lower cross head jaws of the machine. A gradual tensile force was applied at a cross speed of 2 mm/minute. The process was done until the complete debonding of the liner occurred. Then the values are marked.Tensile bond strength was calculated in MegaPascal (MPa) unit. The formula used to determine the tensile strength was,

$$\text{Tensile bond strength} = \frac{\text{Maximum load (N)}}{\text{Cross sectional Area (mm}^2\text{)}}$$

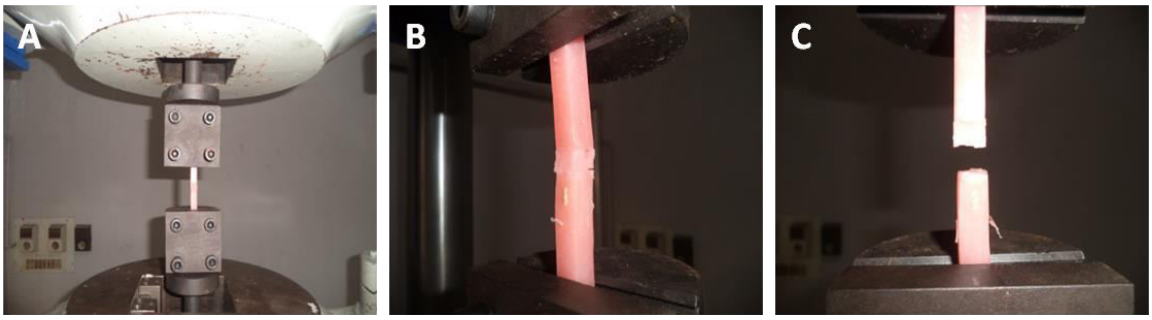

Figure 3: Tensile strength testing. A-C .Evaluation of specimens under Universal Testing machine for Tensile Bond Strength

Statistical Analysis

Statistical analysis was performed using SPSS, Version 22.0. (IBM Corp). Results for categorical data are summarized using frequencies and percentages. Continuous variables are reported as means ± standard deviation. Mann-Whitney U test and one way ANOVA test were used for testing the significance. The value of $p< 0.05$ was considered statistically significant.

Results

Tensile bond strength value of UFi GEL P™ (GROUP I) immersed in water, Fittydent™ and Clinsodent™ for a period of one day and after six months (180 days). The results shows that, Tensile bond strength value of water and Fittydent increased over a period of 180 days, while Clinsodent showed a high significant decrease in the Tensile bond strength value of UFi GEL P™ (Table 1)

TABLE 1: Tensile bond strength value of UFi GEL P™ (GROUP I) after immersion in water, Fittydent™ and Clinsodent™ for a period of one day and 180 days

	WATER		FITTYDENT		CLINSODENT	
SL NO	II A¹ 1 DAY (MPa)	II A² 180 DAYS (MPa)	II B¹ 1 DAY (MPa)	II B² 180 DAYS (MPa)	II C¹ 1 DAY (MPa)	II C² 180 DAYS (MPa)
1	0.87	0.87	0.89	0.89	0.82	0.54
2	0.89	0.89	0.90	0.91	0.83	0.51
3	0.85	0.88	0.89	0.90	0.85	0.58
4	0.87	0.89	0.88	0.92	0.82	0.53
5	0.89	0.90	0.89	0.92	0.82	0.55
Mean	**0.87**	**0.88**	**0.89**	**0.90**	**0.82**	**0.54**

Tensile bond strength value GC RELINE™ SOFT (GROUP I) immersed in water, Fittydent™ and Clinsodent™ for a period of one day and after six months (180 days). The results shows that, Tensile bond strength value of water have no change while, Fittydent showed a slight increase. On the other hand, Clinsodent showed a high significant decrease in the Tensile bond strength value GC RELINE™ SOFT (Table 2)

TABLE 2: Tensile bond strength value of GC RELINE™ SOFT (GROUP II) after immersion in water, Fittydent™, and Clinsodent™ for a period of one day and 180 days

	WATER		FITTYDENT		CLINSODENT		
SL NO	I A¹ 1 DAY (MPa)	I A² 180 DAYS (MPa)	I B¹ 1 DAY (MPa)	I B² 180 DAYS (MPa)	I C¹ 1 DAY (MPa)	I C² 180 DAYS	(MPa)
1	0.72	0.73	0.72	0.74	0.71	0.54	
2	0.72	0.73	0.71	0.75	0.71	0.59	
3	0.74	0.71	0.70	0.73	0.72	0.48	
4	0.73	0.70	0.71	0.72	0.73	0.53	
5	0.72	0.74	0.72	0.75	0.70	0.53	
Mean	**0.72**	**0.72**	**0.71**	**0.73**	**0.71**	**0.53**	

Table 3: Comparing First And 180 Day Tensile Strength Values Of Subgroup I A, I B, I C (Ufi Gel P[tm]) Samples

Subgroup	N	Mean	Std. Deviation	Median	Mean difference	S.D of difference	Wilcoxon signed rank test Z value	P value
1st day A	5	.726	.009	.720	.004	.024	.41	.638
180 days	5	.722	.016	.730				
1st day B	5	.716	.005	.720	.78	.013	1.45	.740
180 days	5	.738	.013	.740				
1st day C	5	.712	.013	.710	.-.022	2.02	.045	.043
180 days	5	.534	.039	.530				

The results showed that, there was no significance difference in subgroups of water and Fittydent. But in Clinsodent group (IC) on 180th day (subgroup I C^2) specimen shows a significant decrease in tensile bond strength (Table 3). The results showed that, no significance difference in subgroups of water and Fittydent. But in Clinsodent group (II C) on 180th day (subgroup II C^2) specimen shows a significant decrease in tensile bond strength (Table 4).

Table 4: Comparing First Day And 180 Day Tensile Bond Strength Values Of SubgroupII A, II B, II C (Gc Reline[t M] Soft) Samples

Subgroup	N	Mean	Std. Deviation	Median	Mean difference	S.D of difference	Wilcoxon signed rank test Z value	P value
1st day A	5	.847	.017	.870	-.012	-.013	1.60	.109
180 days	5	.886	.011	.890				
1st day B	5	.890	.007	.890	-.014	-.014	1.89	.059
180 days	5	.904	.011	.900				
1st day C	5	.828	.013	.820	.286	.021	2.03	.042
180 days	5	.542	.026	.540				

We found a significance difference between Group I and Group II. Group II (GC RELINE™ SOFT) specimen shows significant decrease in tensile bond strength.

Table 5: Comparison between group I and group II

	Sub groups	N	Mean	Std. Deviation	Median	Mann-Whitney Test Z value	P value*
1ST day	Group I A	5	.726	.009	.720	2.65	.008
	Group II	5	.874	.017	.870		
	Group I B	5	.716	.005	.720	2.69	.007
	Group II	5	.890	.007	.890		
	Group I C	5	.712	.013	.710	2.63	.009
	Group II	5	.828	.013	.820		
180 days	Group I A	5	.722	.016	.730	2.63	.009
	Group II	5	.886	.011	.890		
	Group I B	5	.738	.011	.900	.42	.671
	Group II	5	.904	.013	.740		
	Group I C	5	.534	.039	.530	2.66	.008
	Group II	5	.542	.029	.540		

*Mann-Whitney U test

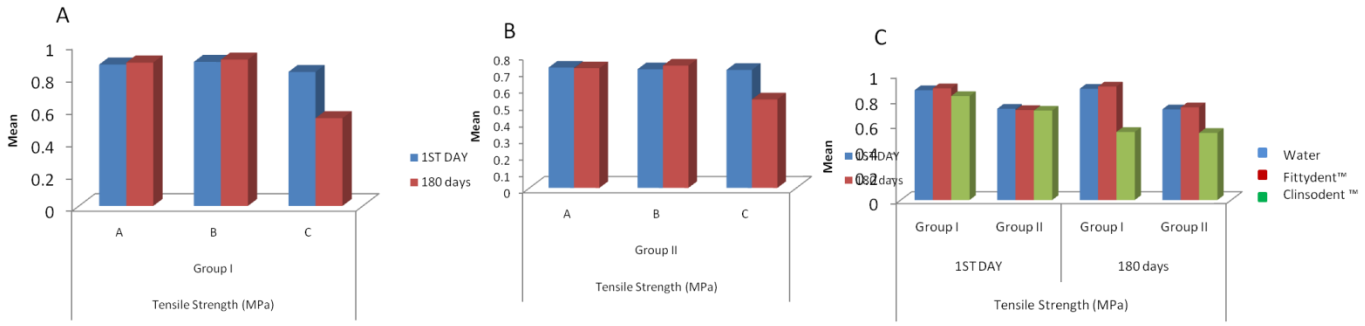

Figure 4: A. Comparison of First And 180 Day UFI GEL PTM. B. Comparison of First And 180 Day GC RELINE™ Soft C. Comparison of Group I and Group II Tensile Bond Strength

Discussion

One of the most clinical challenging issues in Prosthodontics is hardening and debonding of soft liners from the denture base with time. Resilient liners are more preferred to patients with bony undercuts, relief for bruxism, persistent denture sore mouth, radiation therapy, dentures opposing natural dentition, and over implant supported prosthesis especially during healing period.[10, 11]

The two commonly used auto polymerizing addition silicone based lining materials were taken for this study, UFi GEL P™ liner and GC RELINE™ SOFT. TheUfi Gel P™ is a permanent soft addition silicone relining material available in tubes as a two paste system containing base and catalyst. It also provides an adhesive which has silane and 2-butanone. It is indicated in treatment for pressure spot, cushioning of sharp alveolar process, re-adaptation of dentures and permanent soft relining material for full or partial dentures. GC Reline™ Soft is a permanent, soft, resilient, chair-side vinyl polysiloxane denture reline material. It is dispensed in catridge form and it provides an adhesive called GC RELINE™ PRIMER for better bonding between the soft liners and dentures. The bonding between silicone based soft lining materials and acrylics resin assisted by the use of silicone polymer softens the denture base surface when in contact with a volatile solvent or alkylsilane bonding agents. Evaporation of the solvent, the molecules of silicone penetrates into polymethyl methacrylate matrix, which forms a mechanical union on curing stage surface of the liners. After mixing both components, hydroxylation reaction takes place and by adding Si-H from the hydride functional siloxanes which produce bonds across the unsaturated bonds results formation of vinyl functional siloxanes.[12] The most effective cleansing method for dentures is chemical method.Therefore two commonly available denture cleansers of alkaline peroxide were selected for this study. They includes, Fittydent® and Clinsodent®

A total number of 60 specimens were prepared for tensile strength as 60 UFi GEL P™ and 60 GC RELINE™ SOFT. A rectangular block shaped specimen of 30 UFi GEL P ™ and 30 GC RELINE ™ SOFT prepared by using standardized brass mould according to ISO specification NO: 10139. In Water (Subgroup IA) 180 day specimen shows a mean hardness value of 0.88 MPa comparatively lower than first day mean tensile strength value of 0.87 MPa which is found as not significant. In Fittydent (Subgroup IB) 180 day specimen showed a mean tensile strength value of 0.90 MPa which is slightly higher than first day mean hardness value of 0.89 MPa which is found as not significant. In Clinsodent (Subgroup IC) 180 day specimen showed mean hardness value of 0.54 MPa comparatively lower than first day mean hardness of 0.82 MPa which found as highly significant (P< 0.001). GC RELINE™ SOFT showed lower MPa tensile strength value (0.72,0.73, and 0.53 MPa) compared to UFi GEL P™ (0.88,0.90, and 0.54 MPa) in each storage medium over a period of 180 days. It revealed that GC RELINE™ SOFT (Group II) shows an decrease in tensile strength value compared to UFi GEL P™. In the present study Clinsodent® showed a significant decrease in tensile strength. This was in accordance with previous studies.

Tensile strength values of all the resilient liners were lower or similar over a period of 180 days of immersion. Result of this study also supports the study by Mese et al who analyzed the effect of hardness and tensile bond strength. They found that after six months, hardness value of all resilient liner evaluated is varied with increased duration of immersion.[13]

In the present study UFi GEL P™ obtained higher tensile strength (0.73 MPa) reading in Clinsodent® Powder (0.54 MPa) followed by Fittydent® Super Cleansing Tablets (0.73 MPa) and in water (0.72 MPa) compared to GC RELINE™ SOFT liners. After comparing between the mean bond strength, One way analysis of variance data showed *p* value < 0.001 to be very highly significant, which says that there is a significant difference in tensile bond strength among the subgroup. It is found that UFi GEL P™ has adequate tensile bond strength (0.51 MPa)[14] for prosthetic applications. The result contradicted by Aydin et al of UFi GEL P was inadequate.[15] In a study Jagger and Harison (1995)[16] found that the effervescent hygiene agents have a mechanical and chemical cleaning action. These actions results the formation of bubbles which is created by oxygen release during the reaction that may affect the bond

strength. The difference in tensile bond strength between Fittydent and Clinsodent group may be results due to the higher ionic concentration of potassium and sodium present in Clinsodent® Powder contains potassium persulphate, sodium perborate monohydrate, Trisodium phosphate which shares higher ionic concentration in solution that may change the surface properties of silicone liner.

Conclusion

The study evaluated the effect of denture cleansers on tensile strength of two silicone based resilient liners (UFi GEL P™ and GC RELINE™ SOFT). It was observed that UFi GEL P™ is better material than GC RELINE™ SOFT with slight different variations in tensile strength when stored in denture cleanser over a period of 180 days. Inaddition, there is no much significant variation of mechanical properties of soft liners when stored in cleansing solutions and water.

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