Changes in shore hardness and tensile bond strength of selected soft lining materials after storage in artificial saliva and denture cleanser: An *in-vitro* study

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ABSTRACT

Denture liners are applied to the intaglio surface of dentures to achieve a more even force distribution, to reduce localized pressures and to have a cushioning effect between the denture and underlying denture bearing tissues. One of the most clinically challenging issues with these materials is hardening and debonding of soft liners from the denture base with time. The purpose of this study is to assess the effect of saliva and denture cleanser on the hardness and tensile bond strength of different denture liners. Hardness measurements of denture liners specimens will be done using Shore A Durometer and the tensile bond strength measurements of the specimens using Universal Testing Machine.

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INTRODUCTION

Soft denture liners play a vital role in modern removable prosthodontics because of their capability of reducing inflammation of mucosa and restoring health. These materials are applied to the intaglio surface of dentures to have a more equal force distribution and to reduce local pressure points. These liners also provide an even distribution of functional load on the denture bearing tissues avoiding local stress concentration and improving denture retention by engaging the undercuts. These properties make liners very useful for treating patient with atrophic or resorbed ridges, bony undercuts, bruxism, soreness, knife edge ridges, congenital or acquired oral defects requiring obturator, xerostomia patients and during healing period for ossoeintigration

Soft lining materials can be divided into two groups, silicone based and acrylic based. Both are available in autopolymerized or heat polymerized forms.

The initial softness of these materials is due to the presence of large quantity of polymerization in the liquid. However during clinical use with time, these materials undergo two processes when immersed in water: the leaching of plasticizers and other various soluble materials into the water and the absorption of water by the polymer. These changes in loss of softness of denture liner leading to increase in stiffness and hardness of material over a period of time, if the hardness and elasticity of material exceed those of oral mucosa the pressure on tissue increase disadvantageously**.**

To test these hardness changes in denture liners Shore A Hardness has been widely used as it is a simple and reliable test that determines the resistance to the indentation made by a rigid indenter on which forces are applied.

There are several other problems also associated with the use of soft denture liners including detachment of soft liner from denture base, colonization by Candida albicans, porosity and poor tear strength. Bond failure between the resilient liners and denture base is a common clinical occurrence due to immersion of dentures into cleaning solutions or by the effect of saliva in oral cavity.

A variety of evaluations such as peel strength, shear strength and tensile strength test have been used to assess the bond strength of soft denture liners. Among these various tests, tensile strength test induce more separation forces upon bonded area and is considered more effective in evaluation and ranking the materials.

The present study, "CHANGES IN SHORE A HARDNESS AND TENSILE BOND STRENGTH OF SELECTED SOFT LINING MATERIAL AFTER STORAGE IN ARTIFICAL SALIVA AND DENTURE CLEANSER" was undertaken to examine and assess the effect of denture cleanser and artificial saliva on the properties of hardness and tensile bond strength of four auto polymerizing resilient denture liners.

MATERIAL AND METHOD

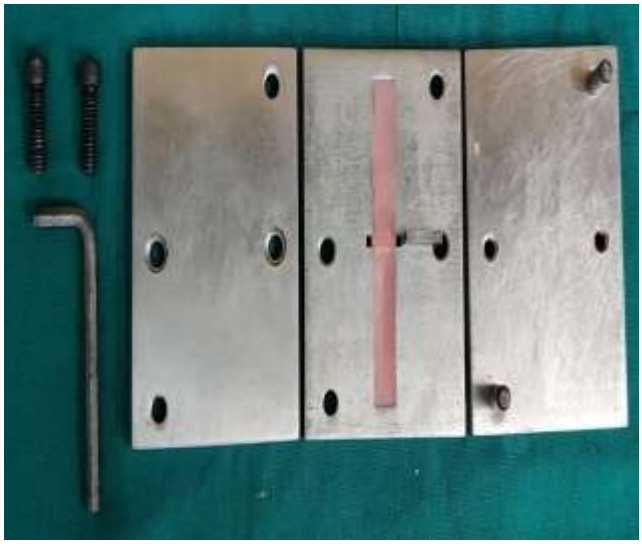


Fig1. Die for tensile bond strength specimen's fig2. Die for shore a hardness specimens

Material	Manufacturer	Type	Adhesive	polymerization
Mollosil	Detax, Germany	Silicon based Soft denture liner	Mollosil Adhesive 03007	Autopolymerization
Gc Reline soft	Gc	Silicon based Soft denture liner	Gc adhesive 1911281	Autopolymerization

Permasoft	Dentsply, Austenal USA	Acrylic based Soft denture liner	-	Autopolymerization
Durabase	Reliance dental, USA	Acrylic based Soft denture liner	-	Autopolymerization
Trevlon	Dentsply, Austenal USA	Heat cure PMMA denture base resin	-	Heat Polymerization

Solutions used for the immersion of specimen were:
1. Clinsodent powder denture cleanser (Sodium perborate) (ICPA Health Products)
2. Artificial saliva (Wet Mouth by ICPA Health Products)

Two custom fabricated dies were used to prepare specimens for measuring tensile Bond strength and shore A hardness.

- First die (fig.1) was used to make specimen of PMMA of dimensions 10×10×40 mm each with 3 mm thick separate removable stainless steel spacer(for resilient liner), for measuring tensile Bond strength.
- Second die (fig.2) was used for fabrication of circular (disc shaped) test specimen of a resilient liner of dimension 30 mm diameter and 3mm thickness (30×3mm), for hardness measurements.

Total samples of Denture liner	**100** Total Specimens							
Type Of Methodology	**40** (circular specimen)*for Shore A Hardness*				**60** (processed with rectangular acrylic blocks) *for Tensile Bond strength*			
Groups	Group 1 **20** Silicon Based		Group 2 **20** Acrylic Based		Group 3 **30** Silicon Based		Group 4 **30** Acrylic Based	
Sub-groups	1A	1B	2A	2B	3A	3B	4A	4B
	Mollosil	Gc reline soft	Permasoft	Durabase	Mollosil	Gc reline soft	Permasoft	Durabase
Artificial Saliva	5	5	5	5	5	5	5	5
Denture cleanser	5	5	5	5	5	5	5	5
Control	-	-	-	-	5	5	5	5

To Measure Hardness:

To measure Hardness group 1 and group 2 will be further divided into two subgroups each based on different materials group:

Group1A – Mollosil (10 specimens)

Group 1B- Gc reline soft (10 specimens)

Group 2A- Permasoft (10 specimens)

Group 2B- Durabase (10 specimens)

The initial hardness will be assessed with shore A Durometer on the samples.

- 5 specimens each from group 1A, 1B, 2A and 2B are immersed in artificial saliva.
- 5 specimens each from group 1A, 1B, 2A and 2B are immersed in denture cleanser.
- Shore A hardness on each sample is carried out at end of 1week, 30days and 90days.

To Measure Tensile Bond Strength:

To measure Tensile Bond strength group3 and group4 will be further divided into two subgroups each based on different materials:

Group 3A- Mollosil (15 specimens)
Group 3B- Gc reline soft (15specimens)
Group 4A- Permasoft (15 specimens)
Group 4B- Durabase (15 specimens)

- 5 specimens each from group 3A, 3B, 4A and 4B are taken as control group.
- 5 specimens each from group 3A, 3B, 4A and 4B are immersed in artificial saliva for 30days.
- 5 specimens each from group 3A, 3B, 4A and 4B are immersed in denture cleanser for 30days.
- All samples were subjected to testing in the Universal Testing Machine at the crosshead speed of 5mm/min, to determine the maximum tensile load before failure.
- Bond strength was calculated as follows: $\frac{Maximum\ load\ before\ failure(kg)}{crossectional\ area(cm^2)}$
- The readings thus obtained from Shore A Durometer and Universal Testing Machine, were tabulated and subjected to statistical analysis.

OBSERVATIONS AND RESULTS

The tensile bond strength and hardness of four soft denture liner materials were evaluated. 60 specimens were tested for tensile bond strength, 40 specimens were tested for hardness after immersion in denture cleanser and artificial saliva.

Statistical constants such as mean and standard deviations were calculated. Data were analyzed, and are expressed in its mean and standard deviation. Analysis of variance (One way ANOVA) was performed as parametric test to compare different soft denture liners.

TABLE 1: Intergroup comparison between different materials when immersed in Saliva at different time interval

Control	Group Ia	25.40	1.140	0.509	24.00	27.00	0.001 (Significant)
	Group Ib	44.00	1.58	0.707	42.00	46.00	
	Group IIa	32.60	3.64	1.630	30.00	39.00	
	Group IIb	31.00	0.771	0.316	30.00	32.00	
Saliva (7 Days)	Group Ia	26.60	.54772	.24495	26.00	27.00	0.001 (Significant)
	Group Ib	50.80	3.03315	1.35647	47.00	55.00	
	Group IIa	31.60	.89443	.40000	31.00	33.00	
	Group IIb	33.00	.70711	.31623	32.00	34.00	
Saliva (30	Group Ia	28.2000	.44721	.20000	28.00	29.00	

Days)	Group Ib	55.8000	1.92354	.86023	53.00	58.00	0.001 (Significant)
	Group IIa	35.8000	.83666	.37417	35.00	37.00	
	Group IIb	36.2000	.83666	.37417	35.00	37.00	
Saliva (90 Days)	Group Ia	31.2000	.83666	.37417	30.00	32.00	0.001 (Significant)
	Group Ib	56.8000	1.64317	.73485	54.00	58.00	
	Group IIa	44.8000	.83666	.37417	44.00	46.00	
	Group IIb	43.8000	.83666	.37417	43.00	45.00	

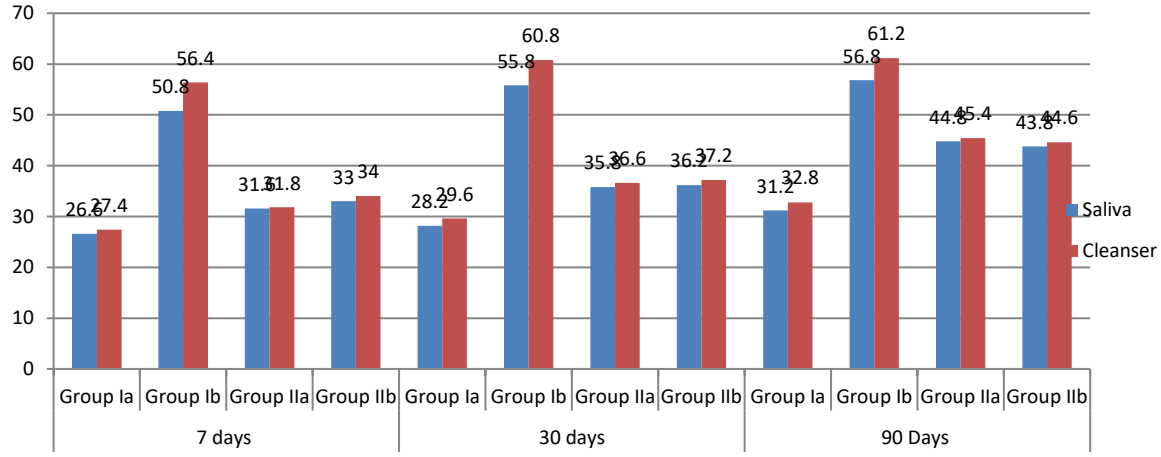
One Way ANOVA at p≤0.05 is significant

TABLE 2: Intergroup comparison between different materials when immersed in Cleanser at different time intervals

	Groups	Mean	Std. Deviation	Std. Error	Minimum	Maximum	P value
Control	Group Ia	25.40	1.140	0.509	24.00	27.00	0.001 (Significant
	Group Ib	44.00	1.58	0.707	42.00	46.00	
	Group IIa	32.60	3.64	1.630	30.00	39.00	
	Group IIb	31.00	0.771	0.316	30.00	32.00	
Cleanser (7 Days)	Group Ia	27.4000	.54772	.24495	27.00	28.00	0.001 (Significant)
	Group Ib	56.4000	1.14018	.50990	55.00	58.00	
	Group IIa	31.8000	.83666	.37417	31.00	33.00	
	Group IIb	34.0000	.70711	.31623	33.00	35.00	
Cleanser (30 Days)	Group Ia	29.6000	.54772	.24495	29.00	30.00	0.001 (Significant)
	Group Ib	60.8000	1.92354	.86023	58.00	63.00	
	Group IIa	36.6000	.54772	.24495	36.00	37.00	
	Group IIb	37.2000	.83666	.37417	36.00	38.00	
Cleanser (90 Days)	Group Ia	32.8000	.83666	.37417	32.00	34.00	0.001 (Significant)
	Group Ib	61.2000	1.78885	.80000	59.00	63.00	
	Group IIa	45.4000	.89443	.40000	44.00	46.00	
	Group IIb	44.6000	.54772	.24495	44.00	45.00	

One Way ANOVA at p≤0.05 is significant

GRAPHICAL REPRESENTATION OF INTERGROUP COMPARISON BETWEEN DIFFERENT MEDIA AT DIFFERENT TIME INTERVALS



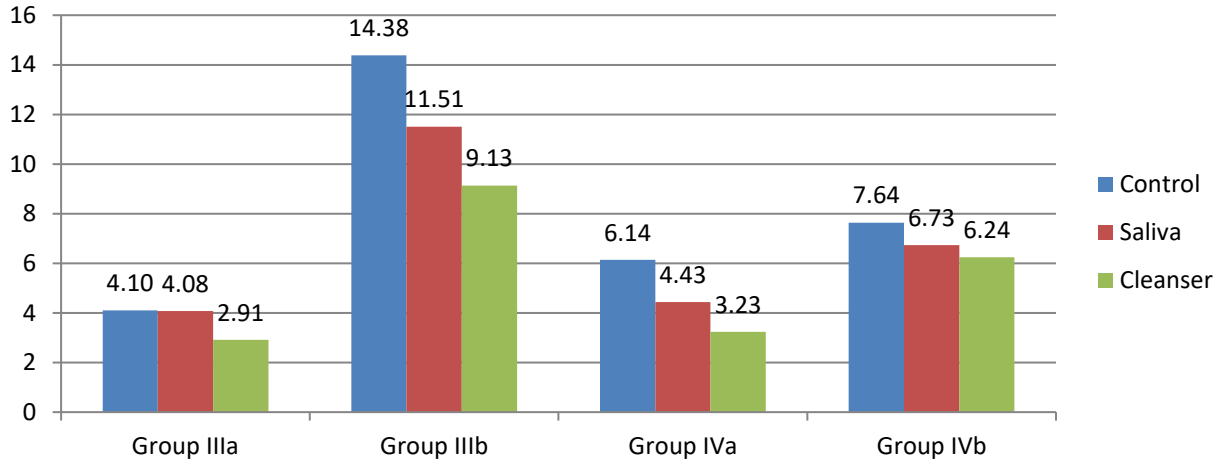
The intergroup comparison of hardness between the materials immersed in saliva and materials immersed in cleanser revealed statistically non-significant difference between the saliva and cleanser for all the materials except for the Material Ib which showed statistically significant difference between the saliva and cleanser at all the time intervals analyzed using Independent t test.

TABLE 3: COMPARISON OF TENSILE BOND STRENGTH BETWEEN DIFFERENT MEDIA

	Control	Saliva	Cleanser	P value
Group IIIa	4.10±0.72	4.08±0.36	2.91±0.56	0.001 (Sig)
Group IIIb	14.38 ±0.86	11.51±1.16	9.13±0.35	0.001 (Sig)
Group IVa	6.14 ± 0.50	4.43±0.74	3.23±0.75	0.001 (Sig)
Group IVb	7.64±0.83	6.73±1.16	6.24±0.76	0.001 (Sig)

The intergroup comparison of hardness between the control group, materials immersed in saliva and materials immersed in cleanser revealed statistically significant difference all the materials except for the Material analyzed using One Way ANOVA.

GRAPHICAL REPRESENTATION OF COMPARISON OF TENSILE BOND STRENGTH BETWEEN DIFFERENT MEDIA



DISCUSSION

Bonding to the denture base surface is a significant problem for resilient liners. Polymethyl methacrylate (PMMA) denture base resin and silicone-based lining materials have different molecular structures and cannot be chemically bonded to each other, whereas acrylic based liners have similar chemical composition to form a chemical bond.

Bonding failure can create an environment for potential bacterial growth and accelerated breakdown of the soft lining material and deterioration of the prosthesis. Saliva and denture Cleanser also produces such conditions. According to literature denture cleansing method is one of the such factors which can modify desirable characteristics of the liners so denture cleanser was induced in study.

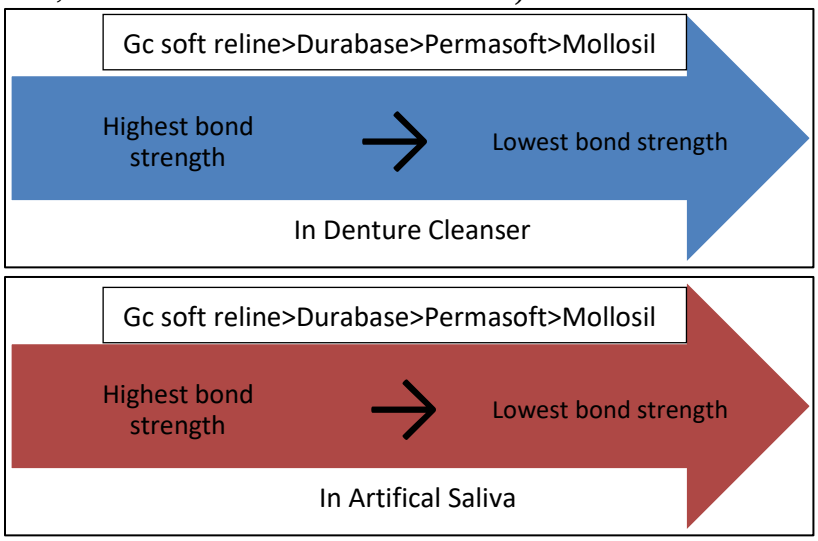
The condition selected for this study was meant to accurately simulate the oral cavity environment because such conditions are more clinically relevant than storage in distilled water so artificial saliva was used as another medium for storage.

Different test to evaluate the adhesive bond strength of materials are peel, tensile, shear, fatigue, creep, impact and cleavage tests Out of all these, commonly used methods to measure bond strength have been peel, tensile and shear tests.

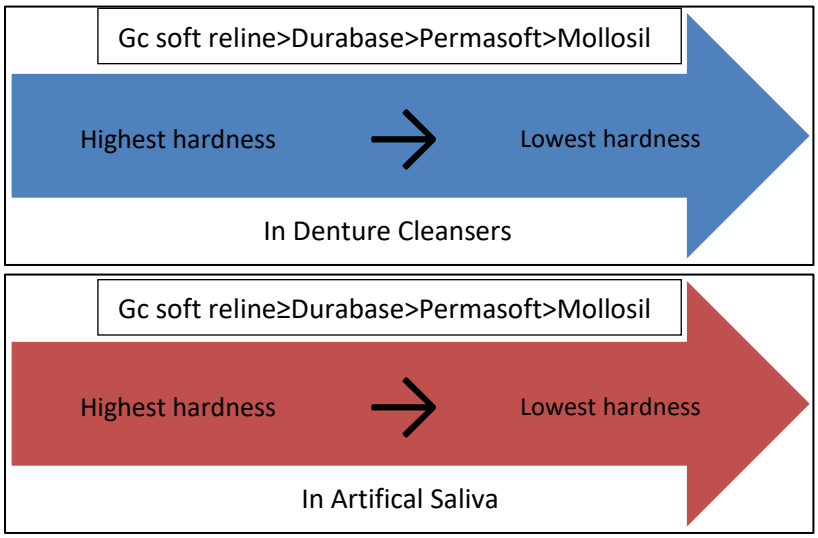
Due to higher probability of cohesive failures in soft materials peel test was not preferred. In shear testing, the stresses applied to the specimen are believed to be concentrated at the edges of the lining material, which makes interpretation difficult therefore tensile test is one of the most preferred**.** This method was endorsed by American Society for Testing and Materials (ASTM) specification D2095-96.

In the present study sodium perborate cleanser and artificial saliva acting upon both silicon and acrylic based soft liner having different mode of action upon denture base are used. Both the solutions (sodium perborate) & (artificial saliva) had decreased the tensile bond strength of four different types of liners (two silicone based and two acrylic based) over the period of time. The comparison between two immersion medium showed statistically significant difference ($p \leq 0.001$) and there was significant difference ($p \leq 0.001$) in tensile bond strength of each denture liner and its sub-group. It has been observed that denture liners demonstrated the best bond strength when they were first bonded to a new acrylic denture base. However, it must be pointed out that bond strength would be comparatively inferior if old dentures are relined. This is

because the acrylic denture base might already be contaminated by microorganisms and other materials absorbed into the denture base from food or cleansing agents. The at least range of 0.45Mpa is to be clinically available for acceptable liners usage. In our study all the tested materials showed higher tensile bond strength than the recommended value. (Gc reline soft- 14.38, Durabase- 7.64, Permasoft- 6.14 and Mollosil- 4.9.)



Water absorbed by the material has both direct and indirect effects on bonding of liners to denture base resin leading to swelling and consequent increase in stress at the liner-denture base interface and reduce the bond strength by causing plasticizers to leach out. The increase in hardness can be attributed to the loss of plasticizers and liquid percolation or absorption by the liners on long term storage in denture cleanser solution and artificial saliva. This increase in hardness can leads to the loss of elasticity and cushioning effect of liners and thus deteriorates its properties.



The Shore A Hardness values at 7days and 30 days for soft lining materials were significantly different with the variation in products. Among the four liners used, the lowest value of tensile bond strength (2.91 kg/cm²) was seen in silicone based liner (Mollosil) after 30 days storage in Sodium Perborate denture cleanser. Among the tested materials, our study also shows, acrylic-based liners are better than silicone based liners in terms of hardness and tensile bond strength.

These results can be explained by chemical adhesion. Chemical adhesion may be explained by the similar chemical composition of acrylic resin and soft liners. For silicone-based liners, most failures were cohesive; likely because of mechanical bonding.

Hence it is proved in this present study, hardness values of resilient liner materials were higher in conjunction with increased duration of storage in different mediums, but bond strength values decrease over a period of time. GC Reline Soft showed the highest durometer Shore Hardness (28 day) value and the highest Tensile Bond Strength value. It can be stated that GC reline soft is an overall harder material and may be more advantageous for patients with less resilient oral tissues. The material with the lowest hardness is the Mollosil and is considered as material of choice in situations requiring lower hardness like acute clinical condition such as healing phase of surgical procedures (Implant, Reconstructive surgery). Though Gc reline soft is a harder material but since its more desirable properties i.e Tensile bond strength is very high even after 90 days period of immersion in both solutions, it is recommended to use this resilent liner in chronic long term clinical condition like bruxism. Permasoft & Durabase due to their optimal properties are suitable for most clinical situation. Selection of a particular liner cannot be based on any single property. Material selection is influenced not only by the properties offered but also by the particular treatment situation.

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