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An In-Vitro Study to Assess the Adhesive Bond Strength of Different Denture Liners

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Abstract

The most common cause of adhesion failure between two materials is the difference in structure. Relining materials are commonly used to reline the tissue surface of the denture. The efficiency of these liners depends on the adhesion between the denture base and liner. This study evaluated and compared the adhesive bond strength of four relining materials to heat-cured resin. The adhesive bond strength of two soft relining materials (Molloplast -B & Silagum-Comfort) and two hard relining materials (Rebase II fast & Ufi Gel-Hard) were done and compared with heat-cured denture base acrylic resin after immersing them in artificial salivary substitute. The strength was evaluated at different intervals. Bond-strength of the liner materials in descending order, as found out in this study is: Rebase II fast, Ufi Gel-Hard, Molloplast -B, Silagum-Comfort. It was also observed from the ANOVA test that there was a statistically significant difference in the adhesive bond strength among the samples at 15 days, 30 days, and 90 days. It was found from the study that hard-liner materials had a greater adhesive bond strength in comparison to soft-liner materials.

Keywords: Denture liner, Strength, Relining materials, Adhesive bond-strength.

Introduction

Esthetics, comfort, and function determine the success of a removable dental prosthesis (1, 2). The prosthesis seats over a supporting tissue area, the denture-bearing area. These tissues sometimes get adversely affected due to increased stress concentration during use. Damage may be in the form of chronic soreness, gradual loss of bone and pathological changes in tissues (1).

Relining is a procedure used for resurfacing the tissue side of the removable dental prosthesis with the new base material. This helps accurately adapt the denture to the denture foundation area (3). It refits the tissue surface of the removable prosthesis, conditions the affected abused tissues, and provides a cushioning effect (4). Denture relining materials can be classified in various ways: a) according to the consistency (hard and soft liners), b) according to the duration of use, c) according to the nature of polymerization, and d) according to the chemical composition. Soft denture liners can be reclassified as permanent and methyl methacrylate-based (acrylic) temporary soft liners. Acrylic temporary soft liners are otherwise called tissue- conditioners. Permanent soft liners can be divided into four types: Auto-polymerized silicone, heat-polymerized silicone, auto-polymerized acrylic resin, and heat-polymerized acrylic resin (5). These materials should comply with ANSI/ADA specification 13 for repairs and with ANSI/ADA specification 17, which sets a margin on the rate of temperature rise and maximum acceptable temperature (6).

These soft denture lining materials have been used for over a century. One of the earliest soft liners used by Twichell in 1869 was soft natural rubber (7). One of the first synthetic resins developed in 1945 was plasticized polyvinyl resin, used as a soft liner. Then silicones were developed in 1950 (8-10). The various physical properties, such as tensile and

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shear bond strengths, depend on the substrate material's composition and relining materials and mainly on their interaction (11). Adhesion may be chemical, mechanical (structural interlocking) or a combination of both (6). This property of remaining nearby due to physical attraction between molecules to a substance or molecular attraction between the surfaces of bodies in contact is significant for the relining material to bond correctly to the substrate, i.e. the tissue surface of the heat cure removable dental prosthesis. This attribute is called bond strength. Since the composition of materials is different, their setting phenomena are also different. Differences in structural composition are among the most common reasons for failure (12). This study assessed the adhesive bond strength of two hard liners and two soft liners to denture base resin, i.e., heat-cured acrylic, over some time. The selected materials are standardized products and their manipulation procedures are feasible according to our current available laboratory conditions. The two soft relining materials were Molloplast -B & and Silagum-Comfort. The two hard relining materials were Rebase II fast and Ufi Gel-Hard.

Materials and methods

As per the diagram, a metal die (Figure 1) was cut from a metal sheet, measuring (Length * Width * Thickness) 16cm * 1cm * 0.2 cm. A single sheet of modelling wax (Cavex, Netherlands) was cut according to the dimensions (Figure 2) and shape of the metal die. One hundred sixty wax specimens were made and flasked in a custom-made flask (Figure 3)

Figure 1: Metal die

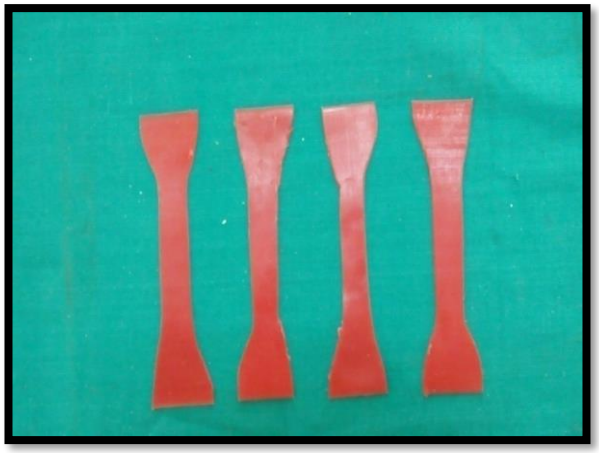

Figure 2: Modelling wax specimens according to the metal die

Figure 3: Custom Made Flask

Figure 4: Group A - Molloplast B

Dewaxing of the wax specimens was done in the dewaxing unit. Heat cure acrylic resin polymer and monomer (DPI) was loaded in the dough stage onto the mould space, and the flask was closed. A hydraulic press was used to apply uniform pressure over the packed resin material. Then, it was left for two hours for bench cure. An Acrylizer unit (Unident) cured the acrylic specimens with a short curing cycle. The acrylic heat-cured resin specimen was allowed to bench cool before deflasking. They were trimmed with the help of acrylic burs to remove the excess and to obtain specimens of the specified dimension. The dimensions were verified with the help of a metallic scale. The specimens were polished and finished. One hundred and sixty specimens were obtained by repeating the same and divided into four groups of forty specimens for each procedure, i.e. Group A- Moloplast-B; Group B- Silagum – comfort; Group C – Rebase II; Group D- Ufi Gel- Hard. All the specimens were marked at the centre, and two more lines were marked at 1 mm aspect on both sides of the centre marking. Then, a straight fissure bur was used to cut the specimens at both the side markings. The two separated segments of the specimens were placed back into the mould space. Petroleum jelly was applied over them. The gap remaining between the two pieces was used to fill the testing liner material.

Forty sectioned samples were taken as Group A samples for Molloplast B (Figure 4). Primo adhesive was applied uniformly with a brush over the bonding surfaces and allowed to dry for 60-90 minutes. Another layer of Primo adhesive was applied and allowed to dry. Then, Molloplast B powder and liquid were mixed in a container. The mixture was then loaded onto the space between the sectioned surfaces of the heat-cured specimens and pressed. Then, they were heat-cured until 100^0 C was achieved for two hours. All the samples were removed from the flask, and the excess was trimmed using the appropriate burs in a dental lathe.

Forty sectioned samples were taken as Group B samples (Figure 5) for Silagum–comfort manipulation. Silagum comfort primer was thoroughly applied over the bonding surfaces and allowed to dry. Then, another layer was applied in the same manner and dried. Silagum comfort varnish was dispensed into the mixing cup with an equal amount from each bottle. Then, it was thoroughly mixed and applied to the prepared surfaces with preventive measures to avoid air entrapment. Then, the material was dispensed from the cartridge through the mixing tip using the cartridge gun. The flask was closed and pressed with the hydraulic press. It was then left for 15 min. to dry.

Forty sectioned samples were taken as Group C (Figure 6) for Rebase II manipulation. The adhesive was first applied on the bonding surfaces of the heat cure material with the help of the supplied brush and allowed to dry. The powder was then first dispensed in a measuring cup. The liquid was taken with the help of a dropper into a rubber cup. The required amount of powder was added to the liquid and mixed with the help of a spatula. After the proper mixture, the material was spread between the gaps with the help of a spatula and the lid of the flask was closed. The flask was then pressed for the uniform spread of material in the mould.

Figure 5: Group B - Silagum Comfort

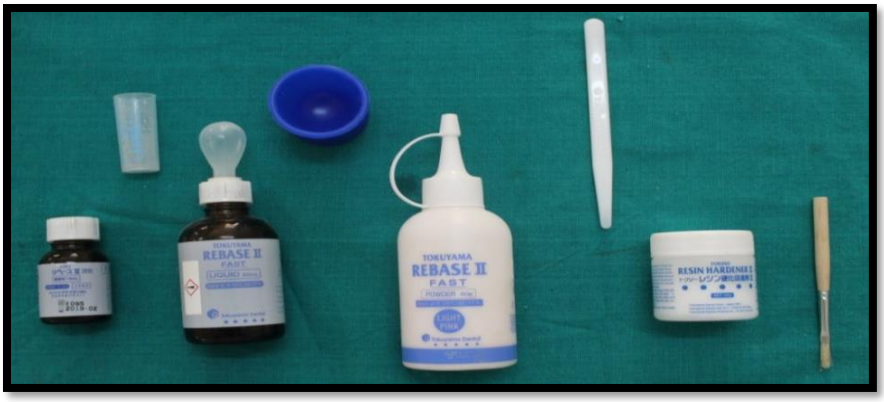

Figure 6: Group C- Rebase II fast

Figure 7: Group D- Ufi-Gel Hard

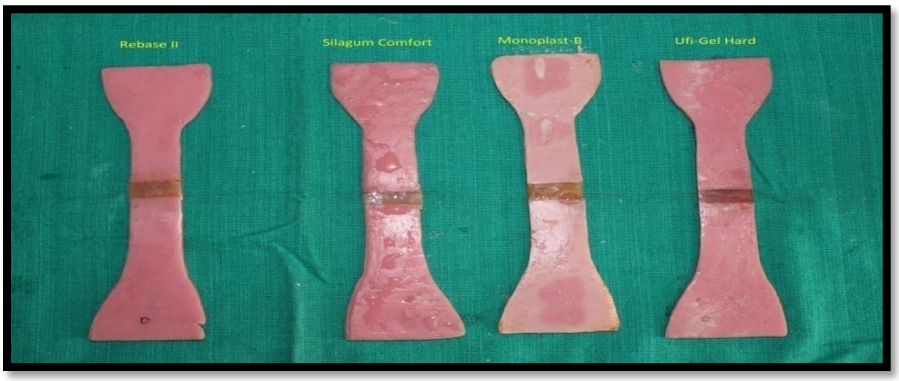

Figure 8: Test Specimens from each group

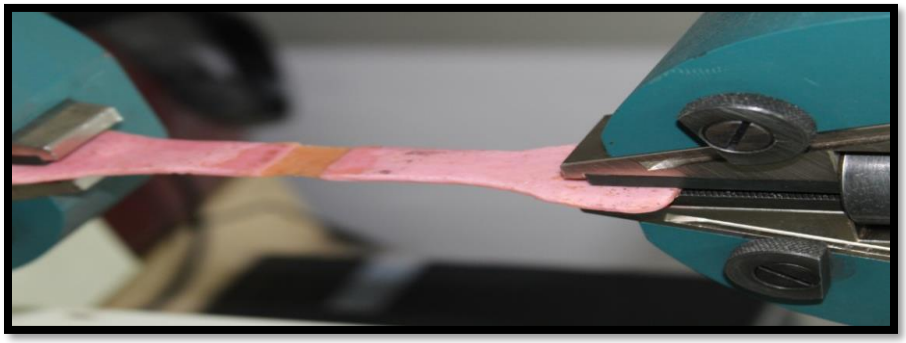

Figure 9: Tinius Olsen testing machine- H50KS with a specimen

Forty sectioned samples were taken as Group D (Figure 7) for Ufi Gel- -Hard manipulation. The conditioner was first applied onto the bonding surfaces of the heat cure specimens, and air dried for 30 sec. The powder was dispensed till the first mark of the graduated glass container. The liquid was dispensed till the second mark of the glass container. First, liquid was dispensed from the measuring glass cylinder to the measuring cup with the help of a dropper, and then the required amount of powder was added. They were thoroughly mixed with a plastic spatula until a homogenous mix was obtained. A separator was applied in the areas of the heat cure specimen where the liner material was not required to adhere. The mixture was pressed into the gap between the sectioned samples in the customized flask.

One hundred sixty prepared samples Figure 8 were taken for ageing. Ageing was done by immersing all the prepared specimens in an artificial salivary substitute (Wet Mouth, ICPA) at a constant temperature of 37 ± 1 degree C maintained in an incubator (Labotech). Forty samples from each group were subdivided into subgroups of 10 each. These samples were taken out at intervals of 0, 15, 30, and 90 days and examined for the adhesive bond strength of the liner material to denture base resin.

At each interval (0, 15, 30, 90 days), ten samples from each group were taken and tested under the tensile testing machine (Figure 9) (Tinius Olsen testing machine- H50KS). The test specimens were stressed until a fracture with a 0.6 cm/min separating speed. The tensile strength values were obtained from the software. The test specimens were stressed until a fracture with a 0.6 cm/min separating speed. The tensile strength values were obtained from the software.

The data collected in the process was entered into SPSS 16.0 software. Comparisons of Sample A, Sample B, Sample C, and Sample D were done. Graphical techniques were used. Tukey HSD analysis was used for inter-group comparisons, and the ANOVA test was used for comparison among and within groups.

Results

The mean value of adhesive bond strength of sample A (Molloplast-B) at 0, 15, 30, and 90 days was found to be 1.72±0.013 Mpa, 1.47±0.012 Mpa, 1.23±0.016Mpa, and 1.03±0.016 Mpa respectively (Figure 10). These values of adhesive bond strength showed a decrease in the adhesive bond strength of Molloplast B over the observed period, with the highest bond strength of 1.72±0.013 Mpa and the lowest of 1.03±0.016 Mpa.

The mean adhesive bond strength of sample B (Silagum-Comfort) to denture base resin at 0,15, 30, and 90 days was found to be 0.62±0.008Mpa, 0.42±0.010Mpa, 0.42±0.010Mpa, 0.32±0.013Mpa respectively (Figure 11). These values showed a decreasing pattern of adhesive bond strength of Silagum-Comfort over the observed period. The highest value of bond strength of Silagum-Comfort was 0.62± 0.08Mpa, and the lowest observed value was 0.32±0.013Mpa.

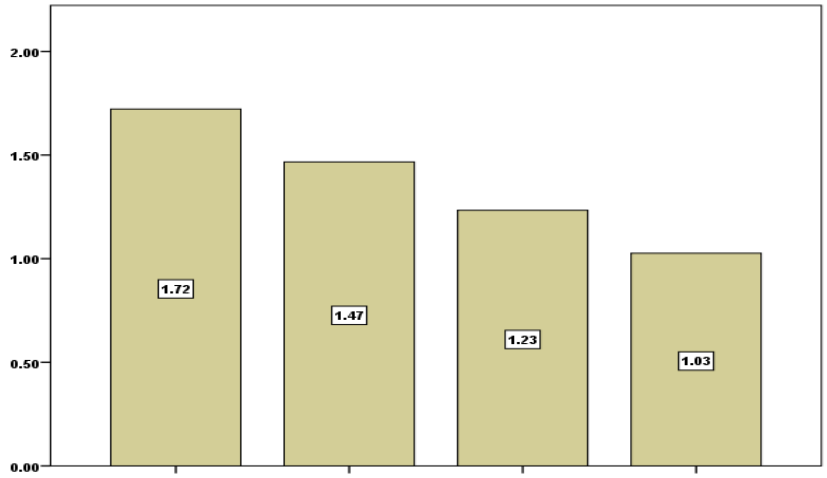

Figure 10: Adhesive bond strength (MPa) of Sample A (Molloplast-B) over the specified period

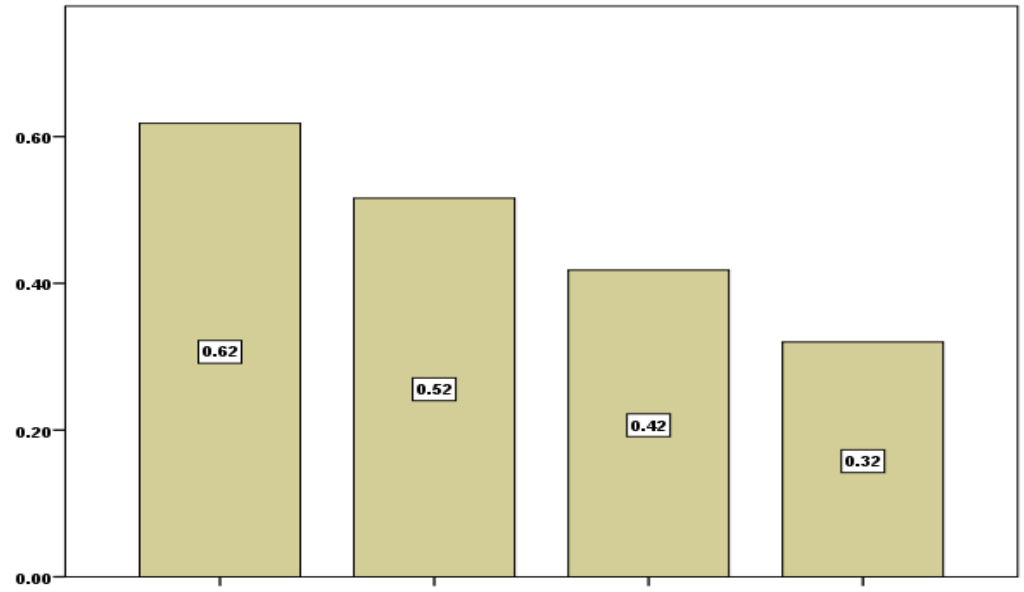

Figure 11: Adhesive bond strength of Sample B (Silagum-Comfort) over the specified period

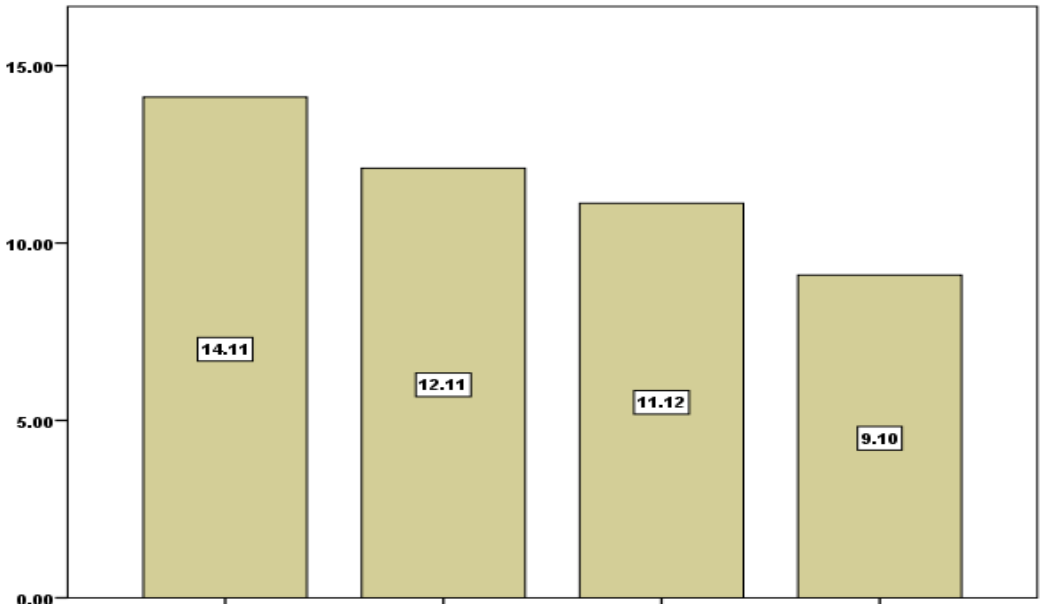

Figure 12: Adhesive bond strength of Sample C (Rebase II fast) over the specified period

The mean adhesive bond strength of Sample C (RebaseII fast) to denture base resin at 0,15,30 and 90 days was observed to be 14.11 ± 0.012Mpa, 12.11 ± 0.008Mpa,11.12 ± 0.008Mpa and 9.10 ± 0.046 Mpa respectively (Figure 12). The maximum and minimum values of adhesive bond strengths of Rebase II fast were 14.11±0.012Mpa and 9.10±0.046 Mpa, respectively.

The mean adhesive bond strength of Sample D (Ufigel-Hard) to denture base resin at the same intervals were found to be 7.02±0.008Mpa, 5.12±0.008 Mpa, 3.52±0.009 Mpa and 4.02 ± 0.009Mpa respectively (Figure 13). The highest adhesive bond strength of Ufigel – Hard was 7.02±0.008Mpa with a decrease in bond strength observed till the 30th day (3.52±0.009 Mpa) and then an increase in values on the 90th day (4.02 ± 0.009Mpa).

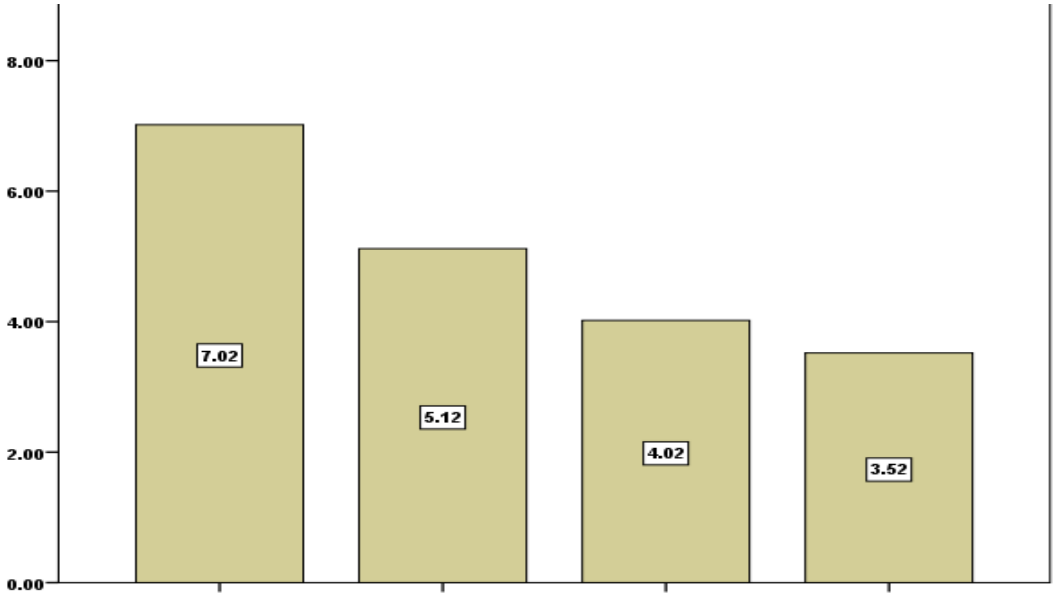

Figure 13: Adhesive bond strength of Sample D (Ufi gel – Hard) over the specified period

Based on the above data, it was concluded that Sample C **(**Rebase II) had the highest adhesive bond strength (14.11 ± 0.012Mpa). In contrast, Sample B (Silagum – Comfort) had a minor adhesive bond strength to denture base resin(0.62±0.008Mpa). The adhesive bond strength of the two hardliners (Rebase II fast and Ufi Gel-Hard) was greater than that of the two soft liners (Molloplast–B and Silagum-Comfort).

Samples comparison at 0 days

Tukey HSD test for multiple comparisons of adhesive bond strength of sample (A) (at 0 days) with other sample groups B, C, and D individually showed a statistically significant difference with a p-value = 0.000 (i.e. $p < 0.05$);. Tukey HSD test for multiple comparisons of adhesive bond strength of sample (B) (at 0 days) individually with the other three sample groups, A, C, and D. showed a statistically significant difference with a p-value = 0.000 ($p < 0.05$). Tukey HSD test for multiple comparisons of adhesive bond strengths of sample group C and Sample group D separately with each of the other three groups (at 0 days) also showed a statistically significant difference with a p-value =0.000($p < 0.05$).

Sample comparison at 15 days

The Tukey HSD test for multiple comparisons of adhesive bond strengths of sample Groups (A), B, C, and Sample Group D (at 15 days) with the other 3 groups also showed a statistically significant difference. (p=0.000).

Sample comparison at 30 days and 90 days

The Tukey HSD test for multiple comparisons of adhesive bond strengths of sample Groups A, B, C, and Sample Group D (at 30 and 90 days) with the other 3 groups also showed a statistically significant difference. (p=0.000). The ANOVA test results of the adhesive bond strengths of the four groups of samples are shown in Table 1.

Discussion

Polyzois found that the bond strength of resilient liners decreased on water storage. [13] The present study's findings are like his findings. However, Craig and Gibbons observed the tensile strength of resilient liner increase with storage in water (14). Mese et al. showed that prolonged exposure to water produced higher hardness values and lower bond-strength values in acrylic resin-based and silicone-based resilient liners (15).

Table 1: Compares the four groups' adhesive bond strength (MPa) at different intervals

Multiple Comparisons							
Tukey HSD							
Dependent Variable			**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Interval**	**Confidence**
						Lower Bound	**Upper Bound**
Day 0	Sample A	Sample B	1.10400*	.00467	0.000	1.0914	1.1166
		Sample C	-12.39200*	.00467	0.000	-12.4046	-12.3794
		Sample D	-5.29600*	.00467	0.000	-5.3086	-5.2834
	Sample B	Sample A	-1.10400*	.00467	0.000	-1.1166	-1.0914
		Sample C	-13.49600*	.00467	0.000	-13.5086	-13.4834
		Sample D	-6.40000*	.00467	0.000	-6.4126	-6.3874
	Sample C	Sample A	12.39200*	.00467	0.000	12.3794	12.4046
		Sample B	13.49600*	.00467	0.000	13.4834	13.5086
		Sample D	7.09600*	.00467	0.000	7.0834	7.1086
	Sample D	Sample A	5.29600*	.00467	0.000	5.2834	5.3086
		Sample B	6.40000*	.00467	0.000	6.3874	6.4126
		Sample C	-7.09600*	.00467	0.000	-7.1086	-7.0834
Day 15	Sample A	Sample B	.95100*	.00422	0.000	.9396	.9624
		Sample C	-10.64300*	.00422	0.000	-10.6544	-10.6316
		Sample D	-3.65100*	.00422	0.000	-3.6624	-3.6396
	Sample B	Sample A	-.95100*	.00422	0.000	-.9624	-.9396
		Sample C	-11.59400*	.00422	0.000	-11.6054	-11.5826
		Sample D	-4.60200*	.00422	0.000	-4.6134	-4.5906
	Sample C	Sample A	10.64300*	.00422	0.000	10.6316	10.6544
		Sample B	11.59400*	.00422	0.000	11.5826	11.6054
		Sample D	6.99200*	.00422	0.000	6.9806	7.0034
	Sample D	Sample A	3.65100*	.00422	0.000	3.6396	3.6624
		Sample B	4.60200*	.00422	0.000	4.5906	4.6134
		Sample C	-6.99200*	.00422	0.000	-7.0034	-6.9806
Day 30	Sample A	Sample B	.81600*	.00486	0.000	.8029	.8291
		Sample C	-9.88800*	.00486	0.000	-9.9011	-9.8749
		Sample D	-2.78500*	.00486	0.000	-2.7981	-2.7719
	Sample B	Sample A	-.81600*	.00486	0.000	-.8291	-.8029
		Sample C	-10.70400*	.00486	0.000	-10.7171	-10.6909
		Sample D	-3.60100*	.00486	0.000	-3.6141	-3.5879
	Sample C	Sample A	9.88800*	.00486	0.000	9.8749	9.9011
		Sample B	10.70400*	.00486	0.000	10.6909	10.7171
		Sample D	7.10300*	.00486	0.000	7.0899	7.1161
	Sample D	Sample A	2.78500*	.00486	0.000	2.7719	2.7981
		Sample B	3.60100*	.00486	0.000	3.5879	3.6141
		Sample C	-7.10300*	.00486	0.000	-7.1161	-7.0899

Day 90	Sample A	Sample B	.70600*	.01139	0.000	.6753	.7367
		Sample C	-8.07000*	.01139	0.000	-8.1007	-8.0393
		Sample D	-2.49300*	.01139	0.000	-2.5237	-2.4623
	Sample B	Sample A	-.70600*	.01139	0.000	-.7367	-.6753
		Sample C	-8.77600*	.01139	0.000	-8.8067	-8.7453
		Sample D	-3.19900*	.01139	0.000	-3.2297	-3.1683
	Sample C	Sample A	8.07000*	.01139	0.000	8.0393	8.1007
		Sample B	8.77600*	.01139	0.000	8.7453	8.8067
		Sample D	5.57700*	.01139	0.000	5.5463	5.6077
	Sample D	Sample A	2.49300*	.01139	0.000	2.4623	2.5237
		Sample B	3.19900*	.01139	0.000	3.1683	3.2297
		Sample C	-5.57700*	.01139	0.000	-5.6077	-5.5463

***. The mean difference is significant at the 0.05 level.**

It was inferred from the ANOVA test that there was a statistically significant difference with a:
1. The p-value =0.000(and F=3441071.388) in 0 days among and within sample groups A, B, C, and D.
2. The p-value =0.000 and F=3284636.963 in 15 days among and within sample groups A, B, C, and D.
3. p-value =0.000 and F=2016402.713 and p=0.000, F=245260.707 respectively for sample groups A, B, C, and D for inter-group and intra-group comparisons at 30 and 90 days.

The results of the present study showed that hard liner materials have a greater adhesive bond strength in comparison to soft-liner materials. Sample A (Molloplast -B) and Sample B (Silagum-Comfort) had an adhesive bond strength of 1.72 Mpa and 0.62 Mpa, respectively, whereas Sample C (Rebase II fast) and Sample D (Ufi Gel-Hard) had an adhesive bond-strength of 14.11 Mpa & 7.02 Mpa respectively. Craig, Gibbons, and Khan et al. claimed that 10 Psi (4.5 kg/cm2) is an adequate adhesive value for an optimal bond (14, 16). In the present study, all liner materials showed a bond strength more significant than the clinically acceptable values. Silagum comfort (6.3 kg/cm2) showed the most minor bond strength but was still greater than optimal bond values.

Out of the four commercially available liner materials which were tested, Sample C (Rebase II fast) showed the highest adhesive bond strength of 14.11 Mpa, whereas Sample B (Silagum-Comfort) showed the lowest adhesive bond strength of 0.62 Mpa. Aydin studied the adhesive properties of 5 liners, two rigid and three soft materials, and studied them after ageing in distilled water for a fixed period. [12] The bond strength of Molloplast B ranged between 1.6 and 1.8 MPa. The bond strength of the hard lining materials, namely Triad and Kooliner, decreased after storage in water, but the bond strength of the control PMMA group increased and reached 42 MPa at the end of the third month of ageing in distilled water. The bond strength of the soft liners behaved differently. There was an increase for Express, a decrease for Ufi Gel-P and almost no change for Molloplast-B observed by ageing and storing them in water. The findings of the present study are like the findings of Aydin.

Lau et al. compared the tensile and shear bond strength of both hard and soft denture-relining materials to conventional heat-cured acrylic denture base resin (17). The study concluded that soft recliners had significantly lower tensile and shear bond-strength values. Mollosil (0.68+0.01 MPa), G C Reline soft (0.54+0.01 MPa), Ufi-Gel-Hard (6.53+0.08 MPa), G C Reline Hard (4.88+0.03 MPa) were found to be adequate for clinical use. Mutluay et al. evaluated the initial bond strength of soft denture-lining materials to denture base materials using different polymerization techniques and with different water content. Vinyl poly(organosiloxane) soft-liners (Mollosil Plus, Dentusil, Ufi gel Soft, GC Reline Soft, Silagum Comfort) and plasticized PMMA soft liners (Vertex Soft) showed similar bond strength. Poly(organosiloxane) based materials exhibited slightly higher bond strength with water-immersed specimens (18).

In all these studies, (12, 17, 18) distilled water was used as the medium for immersion of the specimen. However, the present study used artificial saliva substitutes to simulate the oral cavity environment. This helps validate the findings of the study. Nesrin Anil et al. studied the microleakage of six denture soft liners as an effect of ageing. Flexor and Simpa liners showed the highest microleakage. Mucopren and Molloplast-B showed the lowest micro-leakage (19). Saraç D et al. conducted a study that chemical etchant treatment of denture base resin surface before adhesive application decreased microleakage and increased bond strength (20)

Grzegorz Chladek et al in 2014 reviewed the properties of long-term soft denture lining materials when subjected to ageing and use. Silicone-based long-term soft denture lining materials were more stable and had better hardness, sorption, and solubility than acrylic-based long-term soft denture lining materials (21). When used, liners are constantly bathed in saliva, and when out of the mouth, they are usually immersed in either solution of denture cleansers or water for storage. During such immersion, soft lining materials undergo two responses: leaching out of plasticizers, soluble water, and absorption of saliva. (22, 23). Jepson et al. reported that reductions due to immersion in distilled water, saline, or artificial saliva showed significantly less than those seen clinically (24). Increased loss of plasticizer in clinical conditions was suggestive of an enhanced solvent effect from a dietary source (25).

Garg A et al. evaluated the water sorption and solubility of commercially available acrylic-based self-cure soft denture-lining material after immersion in distilled water, Shelli's artificial saliva, and 5.25% sodium hypochlorite disinfectant solution. The samples were evaluated at 4, 7, 11, and 15 days. The results showed solubility was highest in artificial saliva since it is a mix of various salts and other additives (26). Thus, to assess the effect of microleakage and oral fluids on the bond strength of the liner materials, artificial saliva was chosen as the media for immersion of the specimens. Clinically, the forces to which liner material is subjected are more closely related to shear and tear tests. The shear test is considered ideal for testing the bond strength of resilient denture lining materials (27, 28). In the present study, bond-strength evaluation of the liners was done using tensile testing. However, other physical tests (i.e. shear and tear) should be considered for more appropriate results. Using a closed-loop servo-hydraulic testing system. Pesun *et al.* developed a non-destructive test to evaluate compliance with new soft-liner materials, such as long-term, silicone-based resilient denture liners. This method is sensitive to detect even minor changes (29).

Conclusion

Bond strength is the force required to break a bonded assembly with failure in or near the adhesive /adherend interface [3]. This property is vital for the relining material to bond correctly to the substrate, i.e. the tissue surface of the heat cure removable dental prosthesis. Hence, this study was undertaken. Every endeavour was made to standardize the various procedures in the current study and mimic the clinical scenario. However, further studies are required to validate this study's result on the following basis: a more extended period of observation needs to be recorded; different test methods can be employed; in-vivo studies can be planned; different salivary substitutes can be used.

Abbreviations

Nil

Acknowledgement

None

Author's contribution

DS and AS conceptualized, conducted the study and drafted the manuscript. AS collected and analyzed the data. DS finalized and critically reviewed the manuscript.

Conflicts of interests

The authors do not have any conflicts of interest.

Ethical approval

Approved by the institutional review board. Approval no: SOA/IDS/IRB/7-1/2015

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