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Comparision of the tensile and peel bond strength of the silicone and acrylic soft liner following denture base treatment: An *In vitro* study

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Abstract
Aim: The study was conducted to compare the peel and tensile bond strength of some of the commercially available soft liners with denture base resin and the effect of surface pre-treatment of denture base resin with methyl methacrylate. To compare the tensile and peel bond strength of the auto polymerized acrylic and silicone based soft liners bonded to the heat cure denture base.
Materials and Methods: 80 Acrylic blocks were then divided into 4 groups. Preparation of Blocks and Test samples were done. Tensile bond strength and Peel bond strength were measured.
Results: Use of methyl methacrylate pretreatment for 180 seconds was found to be the most effective method to increase bonding ability of the silicone soft liner to acrylic denture base.
Conclusion: The tensile and peel bond strength of acrylic soft liner bonded to pretreated surface of the acrylic denture base doesn't shows any significant improvement with acrylic soft liner bonded to the untreated surface of the acrylic denture base.

Keywords: tensile strength, peel bond strength, silicone soft liner, acrylic soft liner, heat cure resin

Introduction
Denture irritation with associated pain is one of the most common situations seen in complete denture and partial denture wearers. Hard acrylic denture bases are prone to stress the mucosa beyond its physiological levels of tolerance leading to inflammation and resorption of underlying bone. Soft denture liners are an important substitute in the treatment of removable partial and complete denture patients particularly those who are medically compromised. The study was conducted to compare the peel and tensile bond strength of the currently available soft liners with denture base resin and the effect of surface pre-treatment of denture base resin with methyl methacrylate.

Aim of the Study
To study the tensile and peel bond strengths of the auto polymerized acrylic and silicone based soft liners bonded to the pre-treated heat cure denture base resin with methyl meth acrylate.

Materials and Methods
The materials used are shown in Table 1.

Tensile Bond Strength: A total of 80 acrylic blocks measuring 40 x 10 x 10mm were fabricated in heat cure denture base resin and were ground with 320-grit silicone carbide paper to rectify surface irregularities and excess material. These 80 blocks were then divided into 4 groups

1. Group A
2. Group B
3. Group C
4. Group D

Each group contains ten samples and each sample consists of two acrylic blocks with soft liner interposed.

- Group A and C samples surfaces were not treated with methyl methacrylate.
- Group B and D samples surface were treated with methyl methacrylate for 180 seconds.
- Auto polymerized silicone soft liner were bonded to group A and B
- Auto polymerized acrylic soft liner were bonded to group C and D

Table 1: Materials Used

S. No.	Materials Commercial Name	Type of polymerization	Form of the materials	Manufacturers Name
1	G.C Reline TM Soft (Fig.I)	Auto polymerized silicone soft liner	Supplied as cartridge (base & catalyst)	G.C corporation Tokyo. Japan
2	COE – Softtm Resilient Denture Liner (Fig.IA)	Auto polymerized acrylic soft liner	Powder & Liquid	G.C America Inc. Made in U.S.A
3	Acrylan–H	Heat cure	Powder & Liquid	Asian acrylates
4	Acrylan–H	Heat cure	Liquid (For pre-treatment procedure)	Asian acrylates

Preparation of the Samples

Details of the Metal Dies (Fig. I): Two rectangular steel dies measuring 40 x 10 x 10mm and one steel die for measuring 10 x 10 x 3mm were fabricated and all these surfaces were smooth and flat with sharp edges. Theses steel dies are used to prepare the acrylic blocks and soft liners blocks respectively.

Fig 1: Metal Dies

Preparation of Heat Cured Acrylic Blocks: Mold space was made from one steel die measuring 40 x 10 x 10mm by using addition silicon putty material. Wax blocks were fabricated by pouring the molten wax into the mold space. A total number of 40 wax patterns were fabricated.

Preparation of Mold Space for Liner Placement: The two rectangular steel dies measuring 40 x 10 x 10mm and one steel die measuring 10 x 10 x 3mm were flasked with type II gypsum product. The size 10 x 10 x 3mm steel die placed in-between the two steel dies of 40 x 10 x 10mm. After the flasking procedure was done, the dies were removed to create a mold space of 40 x 10 x 10mm and 10 x 10 x 3mm mold space former is used for placement of acrylic blocks whereas latter one was used for soft liner placement (Fig 2 and 3).

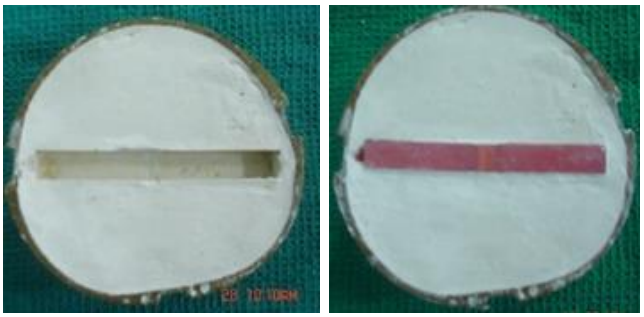

Fig 2, 3: Preparation of Mold Space for Liner Placement

Preparation of Group A Samples: The surfaces of the acrylic blocks to be bonded with soft liner were treated with primer R and dried with clean air and the auto polymerized silicone soft liners were packed into the mold space. After the packing procedure the flask was kept under bench press for 10 minutes.

Preparation of Group B Samples: The surface of the acrylic blocks were pretreated with methyl methacrylate for 180 seconds, and they were left to dry for 2minutes. The primer R was coated gently to the treated surfaces with a brush and dried with clean air and auto polymerized silicone soft liners were packed.

Preparation of Group C Samples: The poly methyl metha-acrylate blocks were placed into the mold space. In between the two acrylic blocks the auto polymerized acrylic soft liners were packed into the mold space.

Preparation of Group D Samples: The surface of the acrylic blocks were pretreated with methyl methacrylate for 180 seconds and left to dry for 2minutes and then acrylic blocks were placed into the mold space. The auto polymerized acrylic soft liners were packed into the mold space.

Peel Bond Strength: A total of 40 acrylic plates of dimensions 75 x 25 x 3mm were prepared in heat cured denture base resin. The polymethyl methacrylate plates were ground with 320-grit silicone carbide paper to remove surface irregularities and excess material. These twenty plates were then divided into five groups.

- Group E
- Group F
- Group G
- Group H

Each group contains 10 samples and each sample consists of one acrylic plate bonded with soft liner.

- Group E and G samples surfaces were not pretreated with methyl methacrylate.
- Group F and H samples surfaces were pretreated with methyl methacrylate for 180 seconds.
- Auto polymerized silicone soft liner were bonded to group E and F
- Auto polymerized acrylic soft liner were bonded to group G and H

Preparation of The Test Samples: Two rectangular steel dies were prepared and it has two parts.

LID: The dimension of the lid is 85mm length X 35mmwidth X 4mm thickness. The surfaces of the lid were smooth, flat and the corners were rounded.

BASE: Base metal die has two sides.

a. One side of the steel die, mold space was prepared for the dimension of 75mm length x 5mm depth x 25mm width. The surfaces of the steel die mold space were smooth, flat and with sharp edges. This mold space was used for soft liner attachment to the polymethyl methacrylate plate.

b. Other side of the steel die has a rectangular shape elevation of 75mm length x 25mm width X 3mm height. This elevated side of the die was used for the preparation of acrylic plate.

Preparation of Acrylic Plates: A modeling wax sheet was used to box the elevated side of the steel die. Die stone was mixed and poured to create a mold space. A total number of twenty-die stone mold space were prepared. Molten wax was poured into the mold space and processing was done by conventional technique. The total surface area of the acrylic plate, the space having the dimensions of 50 mm length X

25 mm width was covered by polyethylene sheet and remaining portion of acrylic plate having the dimensions of 25mm length X 25width mm was left uncovered to facilitate the bonding of soft liner over this surface (Fig 4, 5).

Fig 4: Wax mold

Fig 5: Acrylic Plate

Preparation of Group E Samples: The part of the acrylic plates to be bonded with soft liner were coated with primer R and dried with clean air then it was placed in the mold space of steel die. The acrylic plate occupies the mold space of 75mm length X 25mm width X 3mm depth and the rest of the mold space was left for the auto polymerized silicone soft liner which is packed over the acrylic plates and the soft liner was covered by polyethylene sheet over that lid was placed and it was compressed for 10 minutes under the bench press, the excess materials were removed by scalpel blade. In the prepared sample out of total dimension of 75mm length X 25mm width X 2mm thickness only 25mm length X 25mm width of the liner was bonded to the acrylic plate. The remaining part of the soft liner was not bonded to facilitate the attachment with testing machine.

Preparation of Group F Samples: The surface of the acrylic plates to be bonded with soft liner were pretreated with methyl methacrylate for 180 seconds. The primer R was coated gently over the treated surfaces with a brush and then polymethyl methacrylate plate was placed in the mold space of steel die. The acrylic plates occupies the space of 75mm length X 25mm width X 3mm depth and the rest of the mold space was left for the auto polymerized silicone soft liner, which is packed and it was compressed for 10 minutes under the bench press,

Preparation of Group G Samples: The acrylic plate was placed in the mold space of steel die and it occupied the space of 75mm length X 25mm width X 3mm depth and the rest of the mold space was left for the auto polymerized acrylic soft liner which is packed and it was compressed for 10 minutes under the bench press,

Preparation of Group H Samples: The surface of the acrylic plates to be bonded with soft liner were pretreated with methyl meth acrylate for 180 seconds, and then the specimens were left to dry for 2minutes and it was placed in the mold space of steel die. It occupied the space of 75mm length X 25mm width X 3mm depth and the rest of the mold space was left for the auto polymerized acrylic soft liner which is packed.

Testing the Samples: Tensile and peel bond strength tests were carried out with a universal testing machine named Lloyd instrument. The universal testing machine was connected to an IBM computer. In peel test, the stress is limited to a line at the edge of the joint as the fibers of the soft liners are stretched and pulled away whereas in the tensile test the whole cross sectional area of the bonded surface is under stress.

Tensile Bond Strength: The specimen was fixed to the grip of the Lloyd machine and pulled in either way at a crosshead speed of 5mm/minute was used for this test (Fig.VIII). The maximum tensile load before failure was recorded for each specimen. Tensile bond strength was calculated by the following formula20
Maximum load (N)

$$TENSILE\ BOND\ STRENGTH = \frac{Maximum\ load\ (N)}{Cross\ Sectional\ Area\ (mm2)}$$

The crosshead speed was same for all samples in order to standardize the procedure.

Peel Bond Strength: The specimen was placed in Lloyd universal testing machine at 180-degree angle with the polymethyl methacrylate plate portion in the lower clamp and the soft liner was in the upper clamp. The machine was operated at crosshead speed of 5mm/minute. The maximum load and the soft liner stretched length before failure was recorded for each specimen. The peel bond strength was calculated by the following formula[20]

$$Peel\ Bond\ Strength = \frac{F}{W}\frac{1+\lambda}{2} + 1\left\{\frac{n}{mm}\right\}$$

Results

Tensile and peel bond strength tests were carried out with a universal testing machine named Lloyed instrument. Five samples from each group were tested at a constant cross head speed of 5mm/min[12] (Table 1, 2). The tensile and peel bond strength were recorded. All data's were tabulated and statistical comparisons were made by one-way ANOVA variance and TuRkey-HSD multiple range comparison test.

Table 1: Statistical result of tensile bond strength.

S. No.	Group	Mean	SD	P- value
1	A	1.32b	0.02	<0.001**
2	B	2.12c	0.09	
3	C	0.24 a	0.01	
4	D	0.27 a	0.02	

Note: 1. ** Denotes significant at 1% level.
2. Different alphabet between the groups denotes significant at 5% level

Table 2: Statistical Results of Peel Bond Strength.

S. No.	Group	Mean	SD	P- value
1	E	3.42b	0.19	<0.001**
2	F	4.32c	0.17	
3	G	1.06a	0.16	
4	H	1.14 a	0.07	

Note: 1. ** Denotes significant at 1% level
2. Different alphabet between the groups denotes significant at 5% level

Statistical Analysis

- Overall comparison of groups was done using one-way analysis of variance (ANOVA) with significant at 1%. Level.
- Comparison with in the groups was done using multiple range tests Tukey-HSD test with significant at 5% level

Discussion

Resilient soft liners are widely used in prosthetic dentistry as an adjunct to removable prosthesis to restore the health of the inflamed and abused denture supporting tissues. These materials are commonly used for patients with resorbed mandibular alveolar ridge, thin and no resilient mucosal tissue, maxillofacial defect, patients unable to tolerate the hardness of heat-polymerized acrylic resin denture base and medically compromised individuals.

Resilient soft liners are used to distribute functional loads and reduce the stress concentration on residual ridge and to make dentures more comfortable. the major drawbacks of soft liners is the lack of durable bond to the denture base. The present study was under taken to compare the tensile & peel bond strength of two commercially available soft liners G.C reline soft-Auto polymerized silicone soft liner & Coe-soft-Auto polymerized acrylic soft liner with heat activated acrylic denture base samples. The bonding ability of these resilient soft liners with pretreated and untreated surfaces of acrylic denture base was also evaluated in this study.

From the result of this tensile and peel bond strength test, it was found that the silicone soft liner bonded to the treated surface of the denture base resin with methyl methacrylate for 180 seconds exhibited higher bonding ability than the silicone soft liner bonded to the untreated surface of the acrylic denture base. Mode of bond failure was also observed among the groups of the treated and untreated surface of the denture base. The pretreated surface of the denture base demonstrated primarily cohesive type of failure and the untreated surface shows primarily adhesive type of failure.

- The untreated surface of the acrylic denture base that is abraded with 320-grit silicone carbide paper showed scratches, pores and depressions.
- The pretreated surface of the acrylic denture base with methyl methacrylate for 180 seconds showed smoother surface texture.

The results of the present study revel that treating the acrylic denture base with methyl methacrylate improved the efficiency of bonding between a silicone-based resilient lining material and denture base. A notable limitation of this study is the use of only one type of silicone-based resilient lining material was deployed in the tests. Thus further elaborate study may be much useful to evaluate the effects of the denture base surface pretreatments on the bond strength of different silicone based soft lining materials.

Conclusion

Treating the acrylic denture base surface with methyl methacrylate for 180 seconds significantly improved the bond strength of silicone based soft liner to the acrylic denture base. Considering the results of both tensile and peel bond strength test together, the use of methyl methacrylate pretreatment for 180 seconds was found to be the most effective method to increase bonding ability of the silicone soft liner to acrylic denture base. The tensile and peel bond strength of acrylic soft liner bonded to pretreated surface of the acrylic denture base doesn't shows any significant improvement with acrylic soft liner bonded to the untreated surface of the acrylic denture base.

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