Journal of Indian Prosthodontic Society (March 2010) 10:31–35
DOI: 10.1007/s13191-010-0001-5

ORIGINAL ARTICLE

Comparison of Bond Strength of Auto Polymerizing, Heat Cure Soft Denture Liners with Denture Base Resin - An *In Vitro* Study

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Optimum bond strength between denture soft liner and denture base resin is very important for the success of any denture prosthesis. The tensile bond strength of two commercially available silicone-based heat cured (Molloplast B) and auto polymerizing (Mollosil) was compared with denture base material (trevalon). Molloplast B-trevalon bond in both un-polymerized (dough stage) and already polymerized forms were also compared. Lloyds Universal testing machine was used to test 60 samples. Molloplast B bond strength was greater than Mollosil soft denture liner; it was even greater when packed against trevalon in an un-polymerized form than an already polymerized trevalon using primo adhesive. Both the soft lining materials used are acceptable for clinical usage.

Keywords: Auto polymerizing soft denture liner, Denture base resin, Heat cure soft denture liner, Tensile bond strength

Introduction

Soft denture liners are valuable assets for dentists. They act as shock absorbers; reduce and distribute stress on the denture bearing tissues because of their viscoelastic properties. Chronic soreness is a significant problem for denture patients with diabetes or other debilitating diseases and for many geriatric patients.

Soft denture lining material was first reported in 1943 (Tylman 1943; Popper 1945) [1]. Matthews (1945) [2, 3] introduced one of the first synthetic resins in the form of plasticized polyvinyl chloride.

Today, soft liners are divided into two main types:

A. Plasticized acrylics
B. Silicone elastomers

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One of the very first tests conducted by Bates and Smith (1965) [4] assessed the bond strength of 12 soft liners using tensile test. Kawano et al. (1992) [5] further confirmed and concluded that the tensile test method was effective in ranking the bond strength of 6 soft denture liners to denture base.

Materials and Methods

Materials Used in this study were: (Figs. 1, 2 and 3)

A total of 60 samples were prepared and divided into two main groups.

Group 1: 20 samples of chair side liner Mollosil packed against denture base trevalon.

Group 2: 40 samples of heat polymerizing soft denture liner Molloplast-B packed against denture base trevalon.

Group 2 (subgroup A): 20 samples of Molloplast-B packed against trevalon in an already polymerized form.

Group 2 (subgroup B): 20 samples of Molloplast-B packed against trevalon in an un-polymerized (dough) form.

Material	Manufacturer	Type	Adhesives	Polymerization
Mollosil	Detax Germany	Silicone base	Mollosil adhesive – 03007	Chair side autopolymerization
Molloplast-B	Detax Germany	Heat cure silicone	Primo adhesive – 03004	Heat cure polymerization
Trevalon	Dentsply USA	Heat cure PMMA	_	Heat cure polymerization

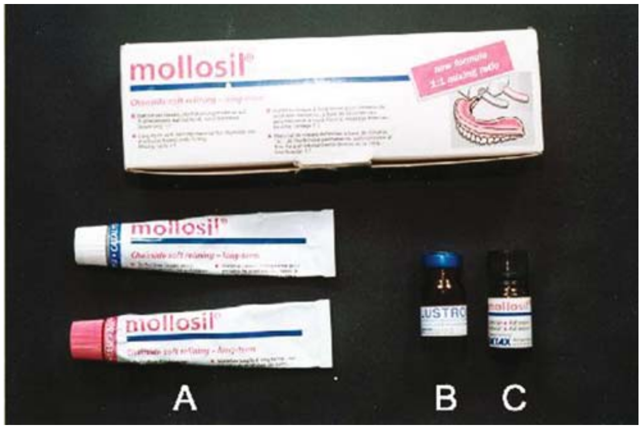

Fig. 1 (A) Mollosil (silicone-based auto polymerizing soft liner), (B) Lustrol, (C) Mollosil adhesive 03007

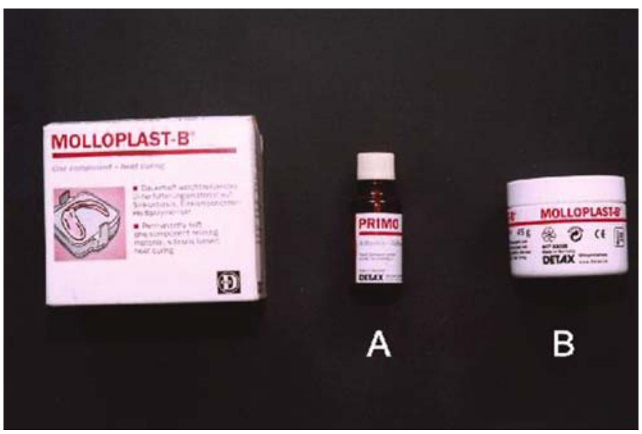

Fig. 2 (A) Primo adhesive 03004, (B) Molloplast-B (silicone-based heat cure soft liner)

Fig. 3 (A) Universal denture liquid (heat cure monomer), (B) Trevalon denture base material (heat cure polymer)

A special flask made of brass was fabricated with a removable 3 mm brass spacer (Fig. 4). The cross-sectional area of liner was 14 × 10 mm^2 and thickness was 3 mm (Fig. 5). A flask with three detachable parts with a sample mold cut out in the middle part was used. All the samples were made to the same dimensions.

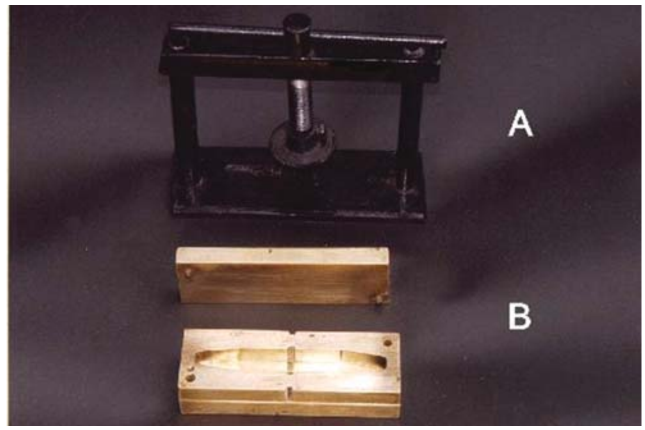

Fig. 4 (A) Clamp, (B) special brass flask with removable 3 mm brass spacer in center

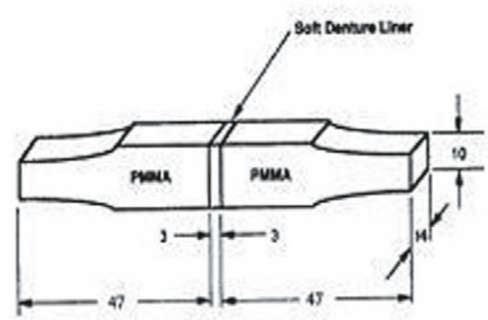

Fig. 5 Diagrammatic representation of sample

Group 1: Two blocks of trevalon were prepared in a water bath by processing resin at 74°C for approximately 2 hours, then increasing the temperature to 100°C and further processing for 1 hour. The brass spacer was in its place while processing. After curing, the flask was bench cooled. The surfaces of the blocks to be bonded to liner were cleaned with fine grit sandpaper. Mollosil adhesive No. 03007 was applied on the dried and degreased surfaces of both blocks for only 1 minute. The blocks were then placed back in the flask. In the space created by the removal of spacer, Mollosil was packed by mixing both tubes according to manufacturer's instructions in the ratio of 1:1. The flask was closed and bench-pressed for about 10–15 minutes and the sample was removed. Twenty such samples were fabricated and subjected to tensile testing.

Group 2 (subgroup A): Fabrication of blocks was done using the same curing cycle as stated above. The blocks were removed and trimmed. The surfaces of denture blocks were cleaned off. Primo adhesive No. 03004 was applied uniformly with the brush one or two times to cover the surface of denture blocks. The blocks were kept to air dry for one-and-a-half hour and then placed back in the flask. Heat cure Molloplast-B soft liner was packed in the space formed by removal of spacer. It was then bench-pressed for 15 minutes at 100–200 kvp. Polymerization was again done by placing the flask in cold water and heating slowly up to 100°C and further keeping it at 100°C for approximately 2 hours. Cooling of flask was done slowly. Twenty such samples were fabricated and subjected to tensile testing.

Group 2 (subgroup B): Trevalon was mixed following the manufacturer's instructions and packed in the dough stage in the flask. The brass spacer was kept in place. The flask was left at 100 kvp for approximately 2 hours under the press. This allowed the dough to reach a firm state that would resist distortion when packed against the soft lining material. After 2 hours, the flask was opened and Molloplast-B packed with the help of clean spatula against acrylic resin dough (un-polymerized form). The flask was then closed and bench-pressed for approximately 10–15 minutes at 100 kvp. Polymerization was done in cold water and slowly heating up to 100°C and further keeping it at 100°C for approximately 2 hours. The flask was cooled down slowly. The sample was removed and trimmed off. Twenty such samples were fabricated and subjected to the tensile test.

All 60 samples were stored dry. They were then deformed at the rate of 2 cm/min. or 20 mm/min. using a Lloyds Universal testing machine linked to an IBM compatible computer (Fig. 6).

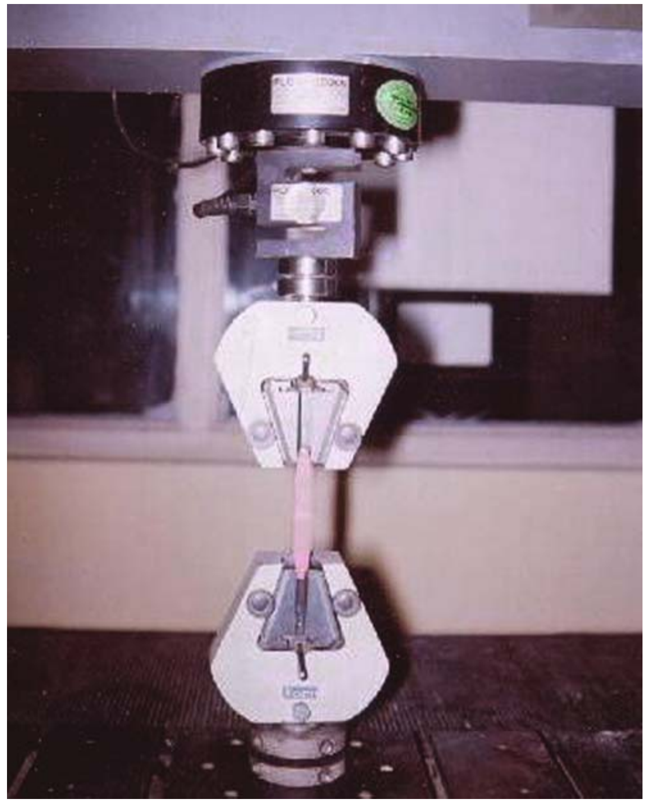

Fig. 6 Sample placed in Lloyds Universal testing machine to test tensile strength

Results

Tensile strength was calculated as follows:

Bond strength = Maximum load (kgf)/Cross-sectional area (mm^2)

kgf stands for kilogram force

The results (Table 1) were subjected to Student 't' test (Table 2) and ANOVA (Table 3).Statistical significance was tested at 5% and 1% probability.

Discussion

The favorable properties of denture liners are; long-term resiliency and good adhesion to denture base material. McCabe et al. (2002) [6] found that the bond strength of soft denture liners to polymethyl methacrylate (PMMA) denture base resins is weak, and when separation takes place the localized area may become unhygienic and non-functional. The bond strength and elasticity values of denture liners vary according to their chemical composition. Silicone soft denture liners are basically dimethyl siloxane polymers without any plasticizer content. As no leaching of plasticizer is present in silicones, they retain their viscoelasticity and softness for longer periods. The disadvantage in using silicone soft liners is presence of little or no chemical adhesion to PMMA denture base resin. Primo adhesives are supplied by manufacturers to aid in bonding of silicone soft denture

Table 1 Basic statistics in respect of tensile strength (kgf/mm^2) of the study groups

Group No.	No. of observations	Mean	SD	CV %	SE of mean	95% confidence interval
1	20	0.100	0.026	26.0	0.006	0.087–0.112
2 (A)	20	0.157	0.027	17.0	0.006	0.144–0.170
2 (B)	20	0.190	0.028	14.6	0.006	0.177–0.203

Table 2 Values of Student's 't' for testing significance of difference among group means for tensile strength

Sample 1	Sample 2	t-statistic			Degrees of freedom	Nature of difference
		Computed	Crit. (5%)	Crit. (1%)		
1	2 (A)	6.678	2.023	2.705	38	Significant at $p < 0.01$ level
1	2 (B)	10.315	2.023	2.705	38	Significant at $p < 0.01$ level
2 (A)	2 (B)	3.725	2.023	2.705	38	Significant at $p < 0.01$ level

Table 3 One way analysis of variance (ANOVA) for testing significance of difference among group means for tensile strength

H_0: Group means are the same
H_1: Group means are significantly different

Source of variation	Degrees of freedom	Sum of squares	Mean squares	Variance ratio (F)		
				Computed	Critical at 5%	Critical at 1%
Between treatments	2	0.0831	0.0415	54.722**	3.162	5.01
Control vs others (G 1 vs G 2)	1	0.0722	0.0722	95.126**	4.012	7.114
Between others (G 2 (A) vs G 2 (B))	1	0.0109	0.0109	14.319**	4.012	7.114
Experimental error	57	0.0433	0.0008			
Total	59	0.1263				

**Significant at $p < 0.01$ probability level

liners with denture base resins. Therefore the bond strength of silicone denture liners depends upon the tensile strength of the materials and adhesive used. Polymerization stage of PMMA denture base resin also plays a very important role in optimizing the bonding. According to McMordie (1989) [7], clinically, the stress exerted on the interface of two materials is more closely related to shear and tear.

Fowler (1968) [8, 9] and Cantor et al. (1969) [10] pointed out that tensile failure was not caused by tensile forces alone because some shear forces are also developed in the tensile test. This occurs because of the high Poisson's ratio of silicone lining materials, where a reduction occurs in the cross-sectional area of the lining materials when it stretches after the application of a tensile load, whereas the bonded portion maintains a constant area. This stretching induces some shear forces at the margin of the bonded surface that may cause the material to fail earlier than it would because of the concentration of forces at the margin of the bond. After the analysis it was concluded that the bond strength of Molloplast-B was greater than the bond strength of Mollosil. Aydin et al. (1999) [11] in a study to compare the bond strength soft lining materials arrived at a similar conclusion. The result of bonding of Molloplast-B soft liner against un-polymerized denture base resin was in accordance with the study conducted by Amin et al. (1981) [12] and Jagger (2002) [13]. It has been reported by Craig (1961) [14] and Khan et al. (1989) [15] that the soft denture materials having a 10 pounds per inch (4.5 kg/cm^2) bond strength are acceptable for clinical use.

Taking these criteria into consideration, both the materials tested had satisfactory bond strength to PMMA denture base resin. Molloplast-B against an already polymerized PMMA showed a higher bond strength than Mollosil against PMMA (15.72 kg/cm^2 or 0.157 kgf/mm^2). This value was higher than that observed by Bates et al. (1965) [4] (13.6 kg/cm^2) and lower than that observed by Khan et al. (1989) [15]

(23.9 kg/cm²). The findings of this study were more or less in line with the bond strength conclusions of the study drawn by Kawano (1992) [5].

Summary and Conclusions

Within the limitations of this *in vitro* study, it was concluded that:

- Tensile test mode used for measuring the bond strength was effective in evaluating and ranking the bond strengths.
- Bond strength of Molloplast-B was greater than bond strength of Mollosil.
- Bond strength Molloplast-B packed against denture base trevalon in an un-polymerized form was even greater than the bond strength of Molloplast-B bonded with an already polymerized trevalon using primo adhesive.
- Adequate adhesive value of soft lining material for clinical usage is considered to be 10 pounds per inch (4.5 kg/cm²) [14, 15]. Since the adhesive bond strength observed in this study was minimum 10.0 kg/cm² (0.100 kgf/mm²), both the soft lining materials used are acceptable for clinical usage.

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