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Evaluation of the Bond Strength of Three Soft Lining Materials to Acrylic Resin Denture Base

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الخلاصة

الأهداف: تهدف الدراسة إلى تحديد تأثير أنواع مختلفة من معالجات الأسطح وأوقات مختلفة من الخزن المائي على قوة الارتباط الشدي لثلاثة أنواع مختلفه من المبطنات الطرية للأطقم السنية. **المواد وطرائق العمل:** تم استخدام 294 عينة لهذا البحث والمعالجات السطحية المستخدمة مع مادة ال (Molloplast-B) شملت تخشين السطح بالسنبلة و استخدام مادة ال (primo adhesive). بالنسبة لمادة ال(Bony plus) وقد تم تخشين السطح بالسنبلة فضلا عن استخدام ال(liner liquid). بالنسبة لمادة ال(G C Reline) حيث تم استخدام طريقة التخشين بالسنبلة فقط، قبل قياس قوة الارتباط الشدي كذلك تم خزن عينات البحث لمادة ال(molloplast _B) لفترات مختلفة هي: (1 يوم وشهر وأربعة أشهر) بينما لمادة ال (Bony plus)و ال(GC Reline) كان الخزن للفترات(يوم واحد وأسبوع وشهر واحد) قبل الفحص. **النتائج:** أظهرت النتائج إن تخشين سطح مادة الاكريل باستخدام السنبلة له تأثير معنوي على قوة الارتباط ألشدي لمادتي ال (GC Relineو Bony plus liner). كذلك أظهرت مادة ال liquid treatment (bony plus liners) تأثيرا معنويا على قوة الارتباط الشدي. واختلاف فترات الخزن بالماء كان له تأثير على قوة الارتباط ألشدي لمادة ال (Molloplast_Bوال GC Reline) بينما لمادة ال (Bony plus) ظهرت زيادة معنوية بعد خزن مائي لمدة شهر. **الاستنتاجات:** من هذه الدراسة نستنتج أنه معالجة السطح لمادة الاكريل المستخدم لقاعدة طقم الأسنان يزيد من قوة الارتباط الشدي للمادة الطرية المستخدمة لمعالجة أسطح الأطقم ، كذلك ظهر اختلاف لتأثير الخزن المائي باختلاف ألماده ألمستخدمه الطرية.

ABSTRACT

Aims: The aims of this study were to evaluate the effect of different surface treatments and different periods of water storage on tensile bond strength of three soft lining materials. **Materials and methods**: Two hundred sixty four (264) specimens have been prepared. Surface treatments used for bonding Molloplast – B liner included roughening acrylic surface with bur, and treatment with primo adhesive. For bonding Bony plus liner, roughening acrylic surface with bur, treatment with liner's liquid and combination of both treatments have been evaluated. For GC Reline liner, roughening acrylic surface with bur has been evaluated.Befor tensile bond testing of molloplast-B liner's specimens they were stored for(1 day or 1 month or 4 months), while Bony plus and GC Reline liners'specimenes were stored for(1 day or 1 week or 1 month) and then tested. **Results:** The results showed that roughening acrylic surface had an insignificant effect on (TBS) of GC Reline liner and Bony plus liner (although these materials showed cohesive failure). Bony plus liner's liquid treatments had significant improvement in (TBS) of this liner. Different periods of water storage had insignificant effect on (TBS) of Molloplast-B liner and GC Reline liner, but (TBS) of Bony plus liner showed significant increasing after 1-month water storage. **Conclusion:** From the results of this study we can concluded that surface treatment to acrylic base improved tensile bond strength of soft lining material ,and the effect of water storage on bond strength differed with different types of soft lining materials.

Key word: soft liner, bond strength, denture base

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INTRODUCTION

Soft lining materials are indicated in a variety of circumstances, but most commonly where the oral mucosa covering the denture–bearing area is locally or generally of inadequate thickness, or where the oral mucosa exhibits a reduced tolerance to the loads applied to it by the denture.(1) In addition, patients with persistent denture--sore mouth are not willing to leave their dentures out of the mouth for any length of time.(2) This can be corrected and the tissues can be returned to health by the use of tissue conditioning materials.(3)

The desirable properties of soft lining materials include: they should be non–irritant, non–toxic, dimensionally stable, have low water absorption and solubility, and permanent resiliency. However regardless of all these desirable properties of a liner, if it does not adhere well to the denture base, the material will not function satisfactorily.[4-5] Problems with the clinical use of soft denture liners include the loss of softness, [6] colonization by *Candida albicans*,[7] plaque and calculus accumulation, porosity and poor tear strength,[1] however, the main problem with soft lining materials in clinical practice is the loss of adhesion at the interface with the denture base resin, which exacerbates most of the above problems.[8,9]

Surface treatments of acrylic denture base have been found efficient to enhance bonding strength of soft liner to acrylic base like roughening, use of solvents, and use of adhesives. [10-13]

MATERIALS AND METHODS

Three different soft lining materials were used in this study as listed in (Table 1). The acrylic denture base and auxiliary materials used are listed in Table (2).

Table (1): Types of Tested Soft Lining Materials.

Product	Type	Manufacturer	Class	Batch No.
Molloplast- B	Heat- curing silicone based soft denture liner	DETAX Ettlinger, Germany	Type B, class 1 One component + primo adhesive	040318
GC Reline	Chair side vinyl ploy-siloxane tissue toning material	GC Corporation, Tokyo, Japan	Ultra soft two paste + adhesive	0201156
Bony plus	Chair side acrylic based soft denture liner	Bony F Heiligkveuz 16, Switzerland	Powder and liquid	EB 56

Table (2): Acrylic Denture Base Resins and Auxiliary Materials.

Product	Type	Manufacturer	Class	Batch No.
Major base 2	Heat- curing acrylic denture base	Major prodotti Dentari SPA, Italy	Type I, class 1 Powder and liquid pink color	OJ 3812
Elite model	Gypsum	Zhermack SPA Rovigo, Italy	Type 3 model Dental stone	2829
ISOL Major	Separating medium	Major prodotti Dentari SPA, Italy	Universal	3800
Cellophane paper		Syria Product		

This study was designated to measure the tensile bond strength of two hundred sixty four (264) specimens of acrylic base materials bonded to three different types of soft lining materials. Specimens of each type of soft lining material were randomly divided into different groups according to the type of surface treatment to acrylic base surface and according to the periods of water storage .

Specimens of Molloplast- B liner (120 specimens) were randomly divided into five groups of twenty four (24) specimens each according to the type of surface treatment used as follows:

Group a: Molloplast- B liner packed to smooth acrylic surface without any surface treatment (represent control group).

Group b: Molloplast- B liner packed to roughened acrylic surface using acrylic bur no. 032.

Group c: Molloplast- B liner packed to smooth acrylic surface treated with primo adhesive (supplied with Molloplast-B liners according to manufacturer instruction).

Group d: Molloplast- B liner packed to roughened acrylic surface using acrylic bur no. 032 and treated with primo adhesive.

Group e: Molloplast- B liner packed to unpolymerized acrylic cylinder and processed together.

Each group (24 specimens) was stored in an incubator in a distilled water at (37 ± 1) °C temperature for three periods of storage(1 day, 1 month and 4 months).

Ninety six (96) specimens of Bony plus liner bounded to Major denture base material were randomly divided into the following groups (of 24 specimens each) according to type of surface treatment:

Group a: Bony plus liner packed to smooth acrylic surface without any surface treatment (represent control group).

Group b: Bony plus liner packed to roughened acrylic surface using acrylic bur no. 032.

Group c: Bony plus liner packed to smooth acrylic surface treated with Bony plus liner's liquid for 180 seconds.

Group d: Bony plus liner packed to roughened acrylic surface using acrylic bur no. 032 and treated with liner's liquid for 180 seconds.

Each group (24 specimens) was conditioned for three periods of water storage(1 day , 1 week and 1 month).

Forty eight (48) specimens of GC Reline liner were prepared and randomly divided into:

Group a: 24 specimens of GC Reline liner packed to smooth acrylic surface treated with liner's primer (represent control group).

Group b: 24 specimens of GC Reline liner packed to roughened acrylic surface with acrylic bur no. 032 and treated with liner’s primer(according to manufacturer's instructions).

Each group (24 specimens) was conditioned the same as specimens of Bony plus liner.

Specimens used in this study are shown in Figure (1)

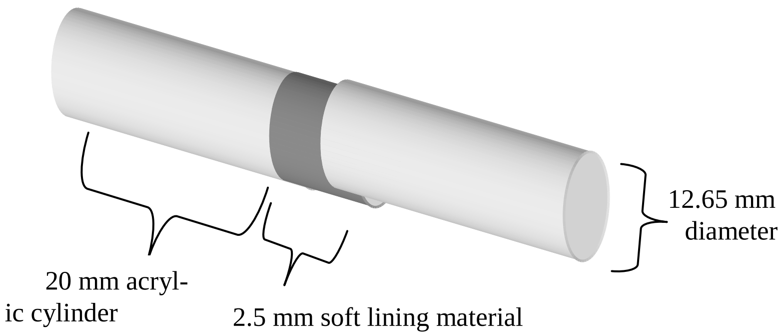

Figure (1): Diagram of Tested Specimen

Split metal mould was used to prepare the acrylic cylinders used by (Kazanji),[14] (Figure 2).

Figure (2): Split Metal Mould for preparing acrylic cylinder.

Preparation of acrylic cylinder and curing was done according to manufacturer's instructions. Dental flask with dental stone (Elite, Zhermack SPA, Rovigo, Italy) as investment material was used to prepare mould for the tensile test specimens Figure (3).

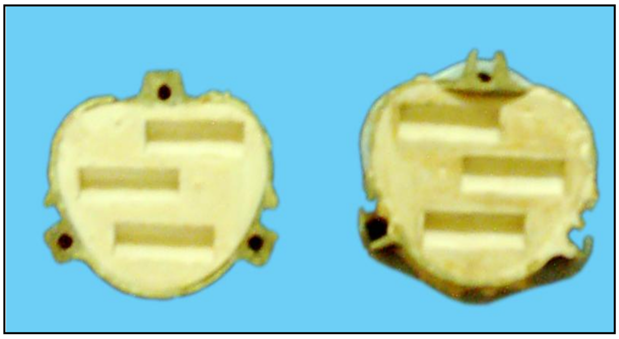

Figure (3): Mould Used in Preparing Tensile Test Specimen.

Pair of acrylic cylinders was placed in the mould (with its bonded surface either treated or untreated according to the group) and then Molloplast- B liner or Bony plus liner or GC Reline liner paste were placed between them then the flask was pressed and cured according to manufacturer's instructions for each material used. A universal testing machine (Zweigle, Semiautomatic strength tester, MILANO) was used to measure the failure load of each specimen, at 50 Kg load cell and 5 mm/ min deformation rate. Mode of failure of each failed specimen was examined visually and by digital light microscope (X 10 magnification).Three way Analysis of variance (ANOVA) and Duncan's multiple range tests were performed in order to compare between groups.

RESULTS

Tensile bond strength (TBS) of three different types of soft lining materials bonded to acrylic denture base material, after different methods of surface treatment, and after storage in distilled water for different periods of time was evaluated.Three way ANOVA (Balanced designs), (Tables 3,4)

Table (3): (ANOVA) of TBS of Molloplast – B Liner Bonded to Major Denture Base for Levels of Surface Treatments, Storage Time and their Interaction

Source of Variance	df	Sum of Square	Mean Square	F- value	*P* - value
Surface treatment	4	46.988	11.7472	115.37	0.000*
Storage time	2	0.1142	0.0571	0.56	0.572
Surface treatment X Storage time	8	3.3098	0.4137	4.06	0.000*
Error	105	10.6909	0.1018		
Total	119	61.1035			

- d.f. = degree of freedom., * mean significant difference.

Table (4): (ANOVA) of TBS of Bony plus Liner for Levels of Surface Treatments, Storage Time and their Interaction.

Source of Variance	df	Sum of Square	Mean Square	F- value	*P* - value
Surface treatment	3	15.5610	5.1870	412.96	0.000*
Storage time	2	2.3574	1.1787	93.84	0.000*
Surface treatment X Storage time	6	1.2721	0.2120	16.88	0.000*
Error	84	1.0551	0.0126		
Total	95	20.2456			

- d.f. = degree of freedom, * mean significant difference.

showed that there were significant differences (*P*< 0.001) in mean TBS of Molloplast – B liner and Bony plus liner after different surface treatments (irrespective to storage time). Duncan's multiple range test (DMRT), (Table 5)

Table (5): (DMRT) of TBS of Molloplast – B Liner Bonded to Major Denture Base after Different Surface Treatment.

Polymerization	Surface treatment	N	Mean (MPa)±SD	DMRT Groups*
Polymerized acrylic denture base	Control	24	0.9547±0.1929	C
	Primo adhesive	24	2.3454±0.4121	A
	Roughening	24	1.3617±0.1658	B
	Roughening + Primo adhesive	24	2.3125±0.3519	A
Unpolymerized acrylic denture base		24	0.9500±0.1306	C

DMRT= Duncan's multiple range test., * =Different letters mean statistically significant difference at *p*≤0.05.

Showed that there was a significant increasing in mean TBS of groups of Molloplast – B liner after different surface treatments when compared with the control groups. Although roughening of the acrylic surface with bur significantly increased mean TBS of Molloplast – B liner, but the highest improvement in mean TBS was observed after primo adhesive treatment to both smooth and roughened acrylic surface. The same table showed that packing Molloplast – B liner to unpolymerized acrylic resin insignificantly decreased mean TBS when compared with the control group. Duncan's multiple range test (Table 6).

Table (6): (DMRT) of TBS of Bony plus Liner after Different Surface Treatment.

Surface treatment	N	Mean (MPa)±SD	DMRT Groups*
Control	24	0.5300±0.0352	B
Liner's liquid	24	1.3683±0.0988	A
Roughening	24	0.6075±0.0358	B
Roughening + Liner's liquid	24	1.3758±0.0466	A

- DMRT= Duncan's multiple range test,* = Different letters mean statistically significant difference at $p \leq 0.05$.

Showed that the liner's liquid treatment to both smooth, and roughened acrylic surfaces significantly increased mean TBS of Bony plus liner when compared with the control group. While roughening of acrylic surface alone had insignificant increasing in mean TBS of Bony plus liner when compared with the control group. Three way ANOVA (Balanced design), (Table 7).

Table (7): (ANOVA) of TBS of GC Reline Liner for Levels of Surface Treatment, Storage Time and their Interaction.

Source of Variance	df	Sum of Square	Mean Square	F- value	*P* - value
Surface treatment	1	0.1397	0.1397	2.99	0.091
Storage time	2	0.0684	0.0342	0.73	0.487
Surface treatment X Storage time	2	0.9770	0.4885	10.44	0.000*
Error	42	1.9650	0.0467		
Total	47	3.1502			

- d.f. = degree of freedom,* mean significant difference.

Showed that roughening of acrylic surface with bur had insignificant effect on mean TBS of GC Reline lining material (irrespective to storage time).

Different periods of water storage had significant effect on TBS of Bony plus liner only, (Table 4), DMRT, (Table 8).

Table (8):(DMRT) for the Effect of Water Storage on Mean TBS of Bony plus Lining Material

Storage Group	Control groups		Tested groups	
	N	*Mean(MPa)±SD	N	*Mean(MPa)±SD
1 day	8	0.268±0.0352 **c**	24	0.995±0.1322 **b**
1 week	8	0.480±0.0616 **c**	24	1.057±0.0988 **ab**
1 month	8	0.841± 0.1060**b**	24	1.298±0.0986 **a**

- DMRT= Duncan's multiple range test, * = Different letters mean statistically significant difference at $p \leq 0.05$.

Showed that there was significant increase in mean TBS of Bony plus lining material after 1 month water storage in both control groups and tested groups. After 1 week water storage there was an increase in mean TBS but it was in significant. The effect of acrylic surface treatment on mode of failure percentage of all lining materials tested are shown in Table (9).

Table (9): Effects of acrylic surface treatment on mode of failure percentage of all lining material tested.

Materials	Mode of Failure Percent for Untreated groups(control)				Mode of Failure Percent for Treated groups			
	N	Adh	Coh	mix	N	adh	coh	Mix
Molloplast-B	24	92	4	4	96	2	50	48
Bony plus	24	71	21	8	72	11	42	47
GC Reline	24	63	0.00	37	24	13	33	54

- adh=adhesive failure, coh=cohesive failure. mix=mixed failure, N=number of samples.

The effect of water storage on mode of failure percentage of all tested materials are shown in Table (10).

Table (10): Effects of water storage on mode of failure percentage of all lining materials tested

Storage Groups	Types of Lining Materials											
	Molloplast-B				**Bony plus**				**GC Reliner**			
	N	adh.	coh.	mix.	N	adh.	coh.	mix.	N	adh.	coh.	mix.
1 day	40	17	43	40	32	41	34	25	16	0.00	31	69
1 week	_	_	_	_	32	3	47	50	16	44	0.00	56
1 month	40	25	40	35	32	3	28	69	16	69	19	12
4 months	40	17.5	40	43	_	_	_	_	_	_	_	_

- adh=adhesive failure. coh=cohesive failure**.** mix=mixed failure, N=number of samples.

The effect of water storage on mode of failures percentage of tested groups of Molloplast – B liner were small. The effect of water storage on mode of failures percentage of Bony plus liner for the tested groups showed that cohesive failures percentage increased after 1 week and 1 month water storage, while adhesive and mixed failure percentage decreased. The effect of water storage on mode of failures percentage of GC Reline liner for the tested groups showed that cohesive failure percentage decreased after 1 week and 1 month water storage, while adhesive failure percentage increased.

DISCUSSION

In the present study roughening acrylic surface with bur significantly improved TBS of Molloplast – B liner (1.3617 MPa) when compared with the control group (0.9547 MPa) as shown in Table (5).

The effect of roughening with bur on TBS of chair side soft lining materials (Bony plus and GC Reline) was insignificant as shown in Tables (6 and 7). Nevertheless, the mode of failures of both materials after surface treatment showed predominant cohesive and mixed mode of failure when compared with the control groups Table (9). These results indicated that the soft lining materials tore before debonding from roughened denture base.

The improvement effect of roughening with bur on tensile bond strength of soft lining materials came in agreement with the results of Kazanji[14] who revealed that irregularities of the acrylic surface provided means for mechanical inter-locking of soft lining material in the hard resin.

The results of the present study contradict the results of other researchers.[15,16] The results of the present study, Table (5), showed that the mean TBS of Molloplast – B liner after primo adhesive treatment to both smooth and roughened denture base surface were significantly higher than control group (2.3454 MPa for smooth base; 2.3125 MPa for roughened base). In addition, this type of surface treatment had the highest TBS values among other types of surface treatments. Mode failures of this group of surface treatment also support the results of TBS Table (9). Silicone base soft lining materials have a chemical composition which differs from acrylic resin denture base therefore there is no chemical bonding between these two materials. An adhesive is supplied with silicone – based soft denture liners in order to aid in bonding the liner to the resin denture base. Therefore, the bond strength of silicone base liners depends on the tensile strength of the material and adhesive used. Without this adhesive, silicone denture base liner has little or no chemical adhesion to PMMA resins. [17, 18]

During manipulation with primo adhesive of Molloplast – B liner, it leaves a layer over acrylic surface after drying. Thus forming a tenacious layer which adheres silicone liner to acrylic base. The chemical components of this primo adhesive were not published, but Minami [12] stated that primo adhesive may consist of an organic solvent and adhesive monomer, which react with both silicone and resin materials.

In the present study, treating acrylic denture base surface with Bony plus liner's liquid also was suggested to improve the weak TBS of this type of liner to denture base. The result of groups of liner's liquid treatment to both smooth and roughened acrylic surface Table (6) showed significant increase in TBS of Bony plus to PMMA (1.3683 MPa for smooth acrylic and 1.3758 MPa for roughened acrylic) when compared with the control group (0.53 MPa).

There is no previous work studied the effect of lining material's liquid treatment on its bond strength to acrylic base. Bony plus liner's liquid composed of Butyl phthalate, Butyl glycolate, Dibutyl phathalate which are plasticizers dissolved in an ethyl alcohol (as listed by the manufacturer). This improving in TBS of Bony plus liner after liner's liquid treatment could be related to the dissolving effect of an ethyl alcohol to acrylic surface. This dissolving effect forms micro pores which enhances mechanical inter-locking and chemical adhesion between liner and denture base ,also promotes penetration of liner material into the denture base. [20]

Packing Molloplast–B liner to un polymerized Major denture base had an insignificant effect on TBS as shown in table (5) (0.9500 MPa for un polymerized and 0.9547 MPa for control), but TBS of Molloplast–B liner to polymerized groups after surface treatment gave a higher bond strength. In spite of that mode of failures percentage showed predominant cohesive and mixed failure. This indicated that packing Molloplast – B liner to un polymerized denture bases had improving effect on bond strength so that the material tore before debonding occurred. These results came in accordance with other researchers.[14,15] This finding suggests the possibility of formation of a simultaneous inter-penetrating network by the molecules of the two materials a cross the interface.

Bond strength of Molloplast-B liner was not affected by water storage Table (3), this came in agreement with some researchers[21,22], but disagreed with others [17, 18] .Although TBS of GC Reline liner was not affected by water storage Table (7), but the mode of failures percentage Table (10) showed shifting toward adhesive failure after water storage. This means that although the effect on TBS was insignificant but there was a decrease in bond strength of GC Reline liner to denture base after water storage. The explanation is that water may percolate directly into the bond site leading to swelling and consequently stress building up at the denture base interface, causing reduction in the bond strength. The indirect effect of water is that it causes changes in the visco elastic properties of the liners.[14,16]

Bony plus lining materials showed a significant increase in TBS after different periods of water storage, Table (8). The explanation to this increase in bond strength after water storage was related to continual polymerization of this material, or due to the release of plasticizer agents to the aqueous environment. As a result of the plasticizer agent solubility, there was less lengthening, and increased rigidity of the material, allowing an increase in the tensile bond strength of the liner.[12, 23, 24]

CONCLUSION

From the results of this study we can drown that surface treatments to acrylic base improved tensile bond strength of all soft lining material tested. water storage has no effect on bond strength of Molloplast-B liner but it decreased bond strength of GC Reline liner and increased bond strength of Bony plus liner.

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