The effect of plasma treatment on shear bond strength of soft denture liner with two different types of denture base material (heat cure and light cure)

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ABSTRACT

Background: In this study we evaluate the effect of plasma treatment (oxygen and argon) gas in two different exposure times on the surface of heat cure and light cure acrylic resin.
Materials and method: 100 specimens of heat cure and light cure acrylic resin were fabricated. The measurements of the samples were (75mm, 25mm and 4.5mm) length, width and depth respectively with stopper of 3mm depth. Two types of gas used oxygen and argon in (5,10) min by using (DC-glow discharge plasma device) then we apply cold cure soft lining material, with the help of Instron machine we test the shear stress value.
Results: A highly significant effect after argon and oxygen gases treatment in both 5 and 10 min exposure times on shear bond strength to soft liner in heat cure denture base material.
Conclusion: In this study we found that the exposure of heat cure acrylic resin to plasma gases (argon and oxygen) increase the shear bond strength (SBS) values significantly.
Key words: Heat cure and light cure acrylic resin, plasma treatment, shear bond strength. (J Bagh Coll Dentistry 2014; 26(2): 44-49).

INTRODUCTION

The most commonly identified problem with denture base incorporating a resilient liner is the failure of the bond between acrylic resin and resilient liner material [1], the most common reason for failure of soft lined denture is the basic structural difference of the two materials [2], several studies have been conducted to improve the bond between the two materials, one of them used different chemical solvents to improve the shear bond strength between different types of denture base materials [3]. Other study to increase the bond between the two materials used sandblasting with different size of aluminum oxide particles, also by chemical etching [2]. All these previous methods have shown to be effective and safe in roughening the surface of materials which subsequently makes the materials more bondable. Plasma is the fourth category of matter that's actually the most unusual and the most abundant. Plasma has been used for a long time for sterilization of medical equipment.

The promise of plasma as a dental preparation will decrease tissue damage and will better prepare the dental surface for composite adhesion [4].

Plasma could be a new painless way to prepare cavities for filling with improved longetivity [5], the plasma is also capable of bacteria inactivation which makes it an attractive tool for the treatment of dental caries and composite restoration [6].

In recent years the plasma arc light have been introduced in dentistry to reduce curing time of light cure composite like for orthodontists to bond brackets, it could be also beneficial in killing the most bacteria present in mouth like s. mutans [7], also studies showed the changes of surface properties of tooth substance using plasma. Yavrich et al [8] which studied the effect of plasma treatment on the shear bond strength between fiber reinforced composite posts and resin composite for core build up and appeared that plasma increase the tensile shear bond strength between them; surface modification by plasma treatment might enable interesting options in dental procedure for better interactions between materials [9].

Several studies conducted about the use of plasma with acrylic denture base materials [10], so far no studies undertake the correlation between plasma and shear strength in acrylic denture base with soft liner, so the present study focused to use two types of denture base material(heat and light) and two exposure times (5,10) min. with argon and oxygen gases.

MATERIALS AND METHODS

This study used two different types of denture base materials; heat cure acrylic resin (Triplex type, Germany) and light cure acrylic resin, one hundred specimens were prepared for shear bond strength test. These specimens were divided into two groups each group subdivided into five subgroups each subgroup consisted of ten specimens (n=10) (control group, 5 min. argon

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gas treated group,10 min. argon gas treated group , 5 min. oxygen gas treated group and 10 min. oxygen treated group).

1. Preparation of the specimen

For both types of denture base materials metal molds were used with the following dimensions as showed in figure (1): (75mm, 25mm, 4.5mm) length, width and depth respectively with stopper of depth about 3mm [11,12]. The thickness of the handle of specimen is 5mm, this is important to have good clamping of the specimen by Instron machine and the force was directed parallel to each other.

A. Heat cure acrylic resin specimens were prepared by coating the metal specimen with separating medium and allow to dry, invested in the lower portion of denture flask that was filled with dental stone (type 3, model-Elite Model thixotropic / Zermack Italy),the stone was mixed according to manufacture instruction, P/L ratio 100g/30ml, after setting of stone both metal pattern and stone were coated with separating medium (cold mould seal), then the upper half of flask was positioned properly and filled with stone mixture. The flask was well covered and left for 1 hour then the flask was opened and the standard specimens were removed. Heat cured resin was mixed according to manufactures instructions, P/L ratio used was 2.3g/1ml, the mixing was done in clean and dry vessel. The acrylic was packed in the dough stage in the mould, the upper half of flask was positioned in its place. Polymerization was carried out according to manufactures instructions by placing the clamped flask in cold water, heat them up to 100 ^{o}C and let them to boil for 45 minutes, after curing the clamp and flask were allowed to cool slowly for 30 min. at room temperature. The acrylic specimens were delivered, finished and polished to put the soft liner material.

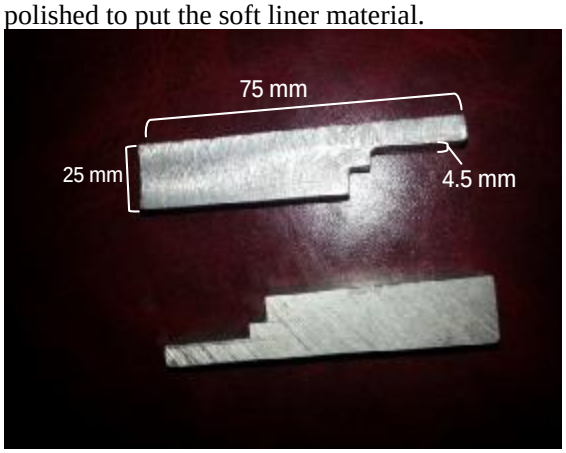

Figure 1: A metal mold for shear bond strength test

B-Light cure acrylic resin groups: as in heat cure acrylic resin denture base material fifty light cured specimens(10 specimens for each group) were made by taking light cure sheet (Vertex LC Trayplates pink, Holland) out of its cover proof, packed and positioned on the mold, the material was adapted in the mold using finger pressure, excess material was removed by cutting using sharp wax knife, curing was done with the light curing unit (Vertex Eco Light Box, Holland) (figure 2) for 10 min. then the mold was inverted and exposed to light for additional 10 min.

Figure 2: Vertex Eco light box

All the specimens (heat and light) were conditioned with distilled water at 37 ^{o}C for 48hours before measuring according to ADA specification No.12.

2-Plasma treatment of the specimens

All the specimens were cleaned for 5 min. using ultrasonic cleaning device then, plasma treatment was done by using a device called DC-glow discharge plasma device (home made) (figure 3), the applied voltage was 650v with direct current density of (o.o3 Ma/cm^{2}), for the two gases used in this study weather argon or oxygen, the same condition conducted for the two types of denture base materials (heat and light).

Figure 3: DC-glow discharge plasma device

The samples were placed on cathode surface in a distance of 4.5 cm between the electrodes. The plasma chamber evacuated before the introduction of the gas to performed the exposure of the surface of the sample to the gas to remove the contaminated layer. After completion of the exposure the samples were covered with cling film before testing. The prepared space between the pair of the specimen was filled with soft lining material according to manufacture procedure (cold-curing silicone based relining material permanently soft (Promedica / Germany).

The material was supplied as (base/catalyst) system, the surface of samples were coated with adhesive material, left for one minute then equal part of base and catalyst were extruded by the gun and mixed, after mixing it is placed under pressure, after complete setting the excess material was removed by sharp knife.

Each specimen was tested using universal Instron testing machine with suitable grips for the test specimen.

The specimens were subjected to 500N load. Cell capacity of cross speed of 0.5mm/1min. until failure occurred was used [(11)].

The value of shear bond strength was calculated for each specimen according to the formula:

Bond strength (N/mm^2) = F/A= maximum load/cross sectional area (ASTM specification D-638m 1986).

RESULTS

Descriptive statistics of the shear bond strength (SBS) in (N/mm^2) of studied groups showed the highest mean value of SBS in heat cure acrylic resin after 5 min argon gas exposure while, the lowest mean value of SBS also after 5 min argon exposure in light cure acrylic resin (tables 1and 2).

Table 1: Descriptive statistics of the shear bond strength (N/mm^2) of light and heat cure acrylic resin to soft liner among the control and argon plasma treated groups (5min. and 10min.)

	Light cure control	After 5 min exposure	After 10 min exposure	Heat cure control	After 5 min exposure	After 10 min exposure
Mean	20.7	18.42	21.08	28.22	48.04	42.47
SD	2.924	2.125	1.881	1.159	2.857	2.683
SE	0.925	0.672	0.595	0.366	0.904	0.849
Min	16.8	14.6	18.4	26.8	42.8	38.6
Max	24.8	22	24.2	30.5	51.2	45.4

Table 2: Descriptive statistics of the shear bond strength (N/mm^2) of light and heat cure acrylic resin to soft liner among the control and oxygen plasma treated groups (5min. and 10min.)

	Light cure control	After 5 min exposure	After 10 min exposure	Heat cure control	After 5 min exposure	After 10 min exposure
Mean	20.7	20.75	21.06	28.22	47.46	46.94
SD	2.924	2.673	2.172	1.159	3.575	3.571
SE	0.925	0.846	0.687	0.366	1.131	1.130
Min	16.8	16.4	18	26.8	38.6	38.9
Max	24.8	24.8	24	30.5	50.8	50.5

Analysis of variance (ANOVA) test showed a significant difference between groups of light cure acrylic resin after argon gas exposure while, a highly significant difference among groups of heat cure acrylic resin after argon and oxygen gas exposure. A non-significant difference between light cure groups after oxygen gas exposure was shown (table 3).

In table (4) the least significant difference LSD test showed a significant difference between control group and 5 min argon exposure group and also between 5 min and 10 min argon exposure groups in light cure studied groups. A highly significant difference between the studied groups of heat cure in two different exposure times and in two gases was shown.

The independent sample t-test showed a significant difference between the two gases after 5 min exposure in light cure groups and between the two gases after 10 min exposure in heat cure groups. A non-significant difference between the two gases after 10 min exposure in light cure groups and between the two gases after 5 min exposure in heat cure groups was shown and highly significant difference between light cure control group and heat cure control group also found (table 5).

Table 3: ANOVA test of shear bond strength among studied groups

Studied groups of argon gas exposure	F-test	P-value		df	Sig	Studied groups of oxygen gas exposure	F-test	P-value		df	Sig
Light cure (control, 5 min, 10 min)	3.737	0.036	Between groups	2	S	Light cure (control, 5 min, 10 min)	0.095	0.909	Between groups	2	NS
			Within groups	27					Within groups	27	
			Total	29					Total	29	
Heat cure (control, 5 min, 10 min.)	187.5	P<0.01	Between groups	2	HS	Heat cure (control, 5 min, 10 min.)	134.08	P<0.01	Between groups	2	HS
			Within groups	27					Within groups	27	
			Total	29					Total	29	

Table 4: LSD test between control groups and the two different exposure times (5 min., 10 min.) of the two different gases (argon and oxygen)

Studied groups	Argon gas exposure	Mean difference	P-value	Sig	Studied groups	Oxygen gas exposure	Mean difference	P-value	Sig
Light cure	Control& 5min	2.28	0.039	S	Heat cure	Control&5min	-19.24	P<0.01	HS
	5min&10min	-2.28	0.017	S		Control&10min	-18.72	P<0.01	HS
Heat cure	Control&5min	-19.82	P<0.01	HS					
	Control&10min	-14.25	P<0.01	HS					
	5min&10min	5.57	P<0.01	HS					

Table 5: t-test between studied groups

	Argon and oxygen 5 min exposure in Light cure	Argon and oxygen 10min exposure in Light cure	Argon and oxygen 5 min exposure in Heat cure	Argon and oxygen 10min exposure in Heat cure	between Light cure control and Heat cure control
t-test	3.231	0.027	0	4.197	7.911
p-value	0.01	0.979	P>0.01	0.002	P<0.01
Sig	S	NS	NS	S	HS

***P<0.05 Significant, *P<0.01 High Significant, **P>0.05 Non significant**

DISCUSSION

Soft liner has been a good help for the dentist because of their act as shock absorber, for patient comfort and for treatment of atrophic ridge and bone undercut all these are positive values but the disadvantages also exist because of the lack of durable bond to the denture [13].

Many researchers suggest roughening the surface to increase the surface area, a study conducted by Craige [14] reported that adhesive effect is obtained with rough surface were approximately double those of smooth surface.

So in this study we tried to improve the bond between soft lining material and two types of acrylic denture base material by using argon and oxygen plasma with two different times to measure the shear stress value.

As we discuss the results we begin firstly by the effect of plasma (argon and oxygen gases)on light cure group which showed a significant differences in SBS values after argon gas exposure (20.7, 18.42, 21.08) mean values in(control, 5 min exposure,10 min exposure) respectively ,these values might be statistically significant but clinically not significant. Hence these values were so close (table 1). A non-significant effect of oxygen gas treatment between the groups of light cure denture base material as showed in table 3.Secondly, we discuss the effect of these two gases on heat cure group, the results showed us a highly significant differences in SBS values after argon gas treatment between the three groups the mean values (28.22, 48.04, 42.47) in (control, 5 min, 10 min) groups respectively .For argon gas we relate its effect of increasing the shear values to physical removal of material when exposed to it which increase surface roughness caused by bombardment of high molecular weight gas particles that improve the micromechanical interlocking between the soft lining material and heat cure denture base material this come in agreement with Gossen et al [15] and with Sladek [16].

On the other hand the results appeared that the 5 min argon gas exposure is the best time for treatment in which this gas is more effective in 5 min, but 10 min exposure was used just to see the effect of lengthening of time [17]. After exposing heat cure samples to oxygen gas the results showed a highly significant differences in SBS values as showed in table 2. The effect of oxygen explained by the etching process by removing from surface material without effecting the bulk, this roughening will enhance the bonding between soft liner and heat cure denture base material [18,19]. Table 5 showed a significant difference in SBS values between the two gases in 5 min time exposure in light cure group which considered statistically different but with no clinical effect as the mean values were so close (18.42, 20.75). A significant difference also between the two gases in 10 min time exposure in heat cure group, which might be due to superior effect of oxygen by chemical oxidation reaction which generate a new chemical functional group on the oxygen plasma treated surface such as hydroxyl group which enhance the penetration of soft liner into the irregularities which enhance the adhesion between the two materials [20,21]. Finally we discuss the highly significant difference between the two control groups (heat and light) which attributed to the difference in material structure and processing method of denture base, also due to the presence of large number of porosities in light cure which could not be kept under pressure so common defect and internal voids could be found [22,23]; this come in agreement with Smith and Chaitanya [24].

In this study we came up with the conclusion that plasma surface treatment (argon and oxygen) of heat cured acrylic resin increase the attachment of soft liner material in two different exposure times (5, 10) min. The effect on light cure denture base material appeared to be non significant.

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