The Effect of Plasma Treatment on Shear Bond Strength of High Impact Acrylic Resin Denture Base Lined with Two Types of Soft Lining Materials after Immersion in Distilled Water and Denture Cleanser

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ABSTRACT

Background: In dentistry, dentist takes the advantages of soft lining materials due to the viscoelastic properties. The major problem is the adhesion of the soft liner with the denture base material.

Materials and Methods: Heat cured of high impact acrylic resin specimens prepared with dimensions 75x13x13mm for shear bond strength test, soft lining material (Refit and Mollosil) with a 3-mm thickness and used to join each two acrylic blocks. Also four specimens with the same previous dimensions utilized for chemical and physical surface analysis. The specimens grouped as control (without plasma) and experiment (with oxygen plasma) treated high impact acrylic specimens.

Results: Plasma treatment increased the shear bond strength for both Refit and Mollosil soft lining material after immersion in distilled water for 30 days as compared with the control group, also there was decrease in shear bond strength for both Refit and Mollosil soft lining material of the experimental group after immersion in denture cleanser for 30 days as compared with the control (without plasma treated) group. AFM analysis revealed that oxygen plasma treatment led to formation of (pits and protuberances) that increase the surface area and increase the shear bond between soft liners and high impact acrylic denture base.

Conclusions: Oxygen plasma surface treatment was an effective method for increasing adhesion by physical topographic surface (due to the plasma etching process which in turn led to removal of some material from the surface and this led to increase the bond strength).

Key words: Plasma treatment, Soft liner material, high impact acrylic resin, Shear bond strength. (J Bagh Coll Dentistry 2015; 27(4):44-51).

INTRODUCTION

Denture fracture is a major problem for patients, dentists, and dental technicians [(1)]. Modifications of acrylic resin composition have been attempt by copolymerization with rubber to produce a high impact acrylic resins [(2)], high impact strength has a desirable properties like and a large yield point distance, high flexural strength, flexural modulus, which aid to resist torsional forces during function, leading to increase the prosthesis clinical service life [(3)].

Soft lining materials are employed to replace the intaglio of a conventional denture (heat cure acrylic denture) to achieve an equal distribution of the force, to reduce confined local pressures and to enhance retention of an ill-fitting denture by involving the undercuts [(4,5)].

According to type of the material, soft liners can be silicone or acrylic based. According to type of curing system, they can be heat-cured or auto-cured, when the dentist can reline a denture directly in the patient mouth. The bond strength of heat-cured materials is greater than that of auto-cured products [(6)].

Denture care is difficult and indispensable for old patients who cannot adequately brush their dentures due to general systemic disease, dementia and poor dexterity [(7)]. Denture cleansers and methods of cleaning used may cause harmful effect on the components of the denture or lead to loss of plasticizers and soluble components, or the resilient lining materials may absorbed water or saliva, which leads to changes in weight that influence their properties, Thus, the denture cleanser selection should be considered to minimize or avoid the changes that may occur in the properties of resilient materials [(8,9)].

Plasma is a mixture of (electrons, ions, free radicals, and excited molecular states) in gaseous forms, created by inelastic collisions between ground state atoms (molecules) and high energy electrons. Plasma treatments of polymer surfaces have been found to enhanced the hydrophilicity without changing the bulk properties of polymers which directly impact their function [(10,11)].

MATERIALS AND METHODS

About 80 specimens made from Impacryl hot (high impact acrylic resin) vertex, Netherland were prepared for shear bond test. The specimens were grouped for each test done in the present study, as control plasma untreated, and oxygen

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plasma treated, each group were divided into 2 subgroup (for Refit- acrylic based and Mollosil-silicone based soft liner) and these subgroups were divided into two subgroups for immersion in distilled water and denture cleanser for 30 days.

Plasma Treatment:

In the present study, a plasma apparatus with parameters: 800 V, 75mA, power 60 W, with 4 minutes exposure time, with the plasma source was kept 4.6cm above the test specimens, were used for all tests of the present study with the application of one type of plasma treatment (oxygen plasma treatments) figure (1).

Shear bond strength testing: A bout 160 blocks made from heat cure high impact acrylic with the dimensions (75mm,13mm, 13mm) length, width and height respectively, in which each (2) specimens were joined by soft liner with a 3-mm thickness [12], to finally reproduce (80) specimens which were grouped as: 40 control specimens without plasma treatment, 40 oxygen plasma treated specimens, each 40 specimens for each group was subdivided into 20 specimens with application of Mollosil soft liner and 20 specimens with application of Refit Soft liner and then 20 specimens were subdivided into two groups (10 specimens for each type of soft liner) for the immersion in both the distilled water and denture cleanser

Figure (1): Plasma Apparature

Figure (2): Plastic Molds for Shear Bond Strength

For tensile bond strength test the following procedures were done:

1. Preparation of acrylic resin blocks:

The high impact acrylic resin specimens were prepared by placing of 2 plastic mold with the dimension of (75mm,13mm,13mm) with stopper of depth a bout 3mm fig (2) for prepared shear bond strength in a silicone duplicating material to get silicone mold for curing of high impact acrylic resin specimens fig (3) (this material can withstand high degree of temperature till 300^0C) then we mixed the high impact acrylic resin (powder and liquid) according to manufacturer instruction, about (21 g) of powder were mixed with (10 ml) of liquid after reaching dough stage we packed the high impact acrylic resin into the silicone mold which was inside the flask then flasking, curing in water path at (70^0C for hour and half an hour then at 100^0C for half an hour) according to the manufacturer instruction then deflasking, finishing of the specimens was done with dental engine and carbide bur at low speed remove any excess material Polishing was continued to remove any remaining small scratches by sandpaper of (120) grain size with continuous water cooling, all surface of the specimens were polished except the surface at which the soft liner were applied by using a lathe polishing machine with bristle brush and pumice. Then the acrylic specimens were conditioned in distilled water at 37^0C for 48 hours according to ADAspecification No.12 1999. After preparation of the specimens and before exposure to the plasma we put the specimens into an ultrasonic cleanser filled with distilled water to clean the specimens, after cleaning we let the specimens to dry on a clean towel ready for oxygen plasma exposure

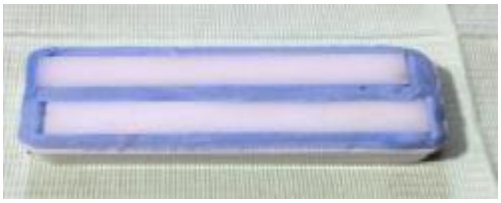

Fig. 3: Fabrication of silicone mold

2. Preparation of the Final Shear Bond Strength Test Specimens:

Reline Material Application:

According to the manufacturer instruction of both soft relining material (acrylic and silicon) soft liner material mixed them. The acrylic type soft liner come in powder and liquid with adhesive, first, put the adhesive and wait for 1min till it dry, then we mixed the powder and the liquid (one spoon of powder to 10 ml of liquid) in clean dry jar and put into the space between the two acrylic block by using spatula, the excess material was removed by using wax knife and a weight of 200g was put over the specimen[13] for

stability until complete setting of reline material was obtained (2min) after that, the specimens immersed in the two solutions (distilled water and denture cleaner).

The silicone soft liner come into 2 past (base and catalyst) first the bonding agent was applied, and on a paper pad, we put the same amount of both base and catalyst and mixed till we obtain a homogenous mix (30 seconds) and then we put it in the space between two acrylic block by using spatula, any excess material was removed by wax knife and the specimen was put under weight of 200 g [13] for stability until complete setting of reline material was obtained (5min). After that, the specimens immersed in the two solutions, distilled water and denture cleaner for 30 days.

Figure (4): Final Specimens during Setting of Soft Lining Materials

Preparation of Denture Cleanser Solution:

The present study used Corega tablets denture cleanser, the composition as shown in the table (1) below.

Table (1): Composition of Corega Tablets denture cleanser

Product	Compositions	Manufacture
Corega	Sodium carbonate Sodium bicarbonate potassium caroate citric acid Sodium carbonate peroxide Sodium benzoate Sodium lauryl sulfoacetate	Block drug company Inc., USA

The solution was prepared for Corega tablets by dissolving one tablet in 200ml of warm water at 40^0C according to manufacturer instruction. After preparation of final specimens and preparation of denture cleanser (40 specimens) they are immediately immersed into the denture cleanser so that they are completely covered with this solution and left the specimens soaked in this solution for 30 days (5hour/day in denture cleanser [15] and then the specimens removed from the cleanser rinsed thoroughly for a few seconds under running water and soaked in distilled water[16].

Figure (5): Corega Tablets Denture Cleanser

1. Testing of the Specimens Stored in Distilled Water:

The specimens were immersed in distilled water at 37 ^{0}C for 30 days, then the sample were removed from distilled water and tested for shear bond strength by Instron testing machine.

The specimens were subjected to shear load with cross head speed (0.5mm/min) using load capacity (100 Kg). Calculated of shear bond strength for each specimen was measured as (the force at the debonding divided by a cross-section area of interface) according to the following formula:

Bond strength=F (N)/A (mm2) (ASTM. specification, D-638 m, 1986)

F= force of failure (Newton)

A= surface area of cross-section (mm^2).

2. Testing of the Specimens Stored in Denture Cleanser:

The specimens were immersed in denture cleanser for 30 days, then the sample were removed from distilled water (because the immersed period was for 5 hours at 40^0C first then on distilled water at 37^0C), then we remove the specimens from distilled water and leave them until dry on air in a clean towel, after drying we measured the shear bond strength by Instron testing machine.

Figure (6): Instron Machine for Measuring Shear Bond Strength

RESULTS

Shear Bond Strength Test:

Mean and standard deviation values of shear bond strength (Map) of resilient liner (silicon and acrylic) soft liner to heat cure high impact acrylic with and without oxygen plasma treatment and after immersion in both distilled water and denture cleanser for 30 days and the comparison between the groups (with and without oxygen plasma treatment) are listed in table (2)

The table (2) revealed that the highest mean value (0.213 N/mm2) for silicone soft liner after immersion in denture cleanser 30 days for the control group (without oxygen plasma treatment), while the lowest mean valuewas for acrylic soft liner (0,098 N/mm2) after immersion in distilled water for the control group (without oxygen plasma treatment).

Physical or Topography Surface Analysis (Atomic Force Microscopy or AFM Analysis):

The surface topography/morphology of the untreated and oxygen plasma treated high impact acrylic specimens was analyzed and compared by atomic force microscopy. Also, the specimen dimensions' for (AFM) analysis were, 75x13x13mm, as the same dimensions which were usedfor shear bond strength test.AFM image show for the surface of high impact acrylic resin specimens (for both control and oxygen plasma treated)specimens, as in figure (7) which is for the control specimen (without oxygen plasma treatment) showed the unevenly distributed granular film in which the nanograin were large, with decrease average diameter and decreased in their number as compared with nanograin that found on the oxygen plasma treated specimen which have small, small average diameter and increased in their number and the distinct appearance of protuberance, crater like and peaks as in figure (8).

Table (2): Descriptive Statistics of the Effect of Plasma Treatment on the Shear Bond Strength of the Two Soft Lining Materials after Immersion in Different Media (Distilled Water and Denture Cleanser)

Materials	Media	Groups	Descriptive statistics			Comparison			
			N	Mean	S.D.	t-test	d.f.	p-value	Sig.
Silicon	Distilled water	Control	10	0.056	0.009	-15.364	18	0.000	HS
		Study	10	0.130	0.012				
	Denture cleaner	Control	10	0.213	0.016	14.913	18	0.000	HS
		Study	10	0.125	0.009				
Acrylic	Distilled water	Control	10	0.098	0.011	-0.798	18	0.435	NS
		Study	10	0.101	0.007				
	Denture cleaner	Control	10	0.120	0.017	0.702	18	0.492	NS
		Study	10	0.115	0.012				

Table 3: Effect of immersion in different media on the S.B.S between high impact acrylic resin denture base and the soft lining materials in control and study groups

		Control (without oxygen plasma treatment)				Experimental (with oxygen plasma treatment)			
Materials	Media	t-test	d.f.	p-value	Sig.	t-test	d.f.	p-value	Sig.
Silicone	Distilled water x Denture cleanser	-26.480	18	0.000	HS	1.025	18	0.319	NS
Acrylic	Distilled water x Denture cleanser	-3.451	18	0.003	HS	-3.213	18	0.005	HS

Table 4: Effect of soft lining materials on the shear bond strength between high impact acrylic resin denture based and the soft lining materials after Immersion in both media in control and study groups

		Control (without oxygen plasma treatment)				Experimental (with oxygen plasma treatment)			
Media	Materials	t-test	d.f.	p-value	Sig.	t-test	d.f.	p-value	Sig.
Distilled water	SiliconxAcrylic	-9.092	18	0.000	HS	6.363	18	0.000	HS
Denture cleaner	SiliconxAcrylic	12.667	18	0.000	HS	2.001	18	0.061	NS

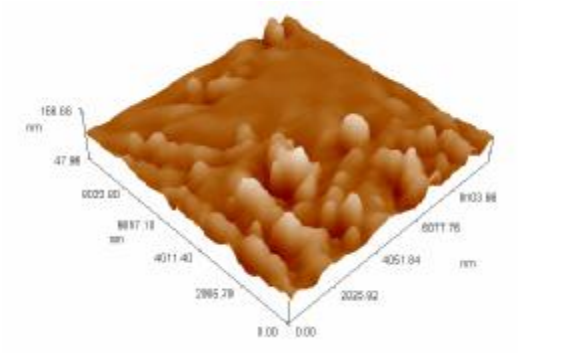

Figure (7): AFM Image for Control (Without Oxygen Plasma) High Impact Acrylic Specimen: 3 Dimensions Image

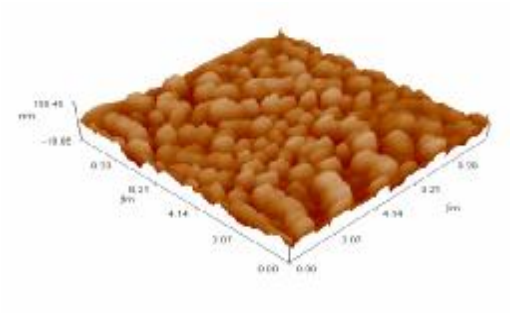

Figure (8): AFM Image for Oxygen Plasma Treated High Impact Acrylic Specimen: 3 Dimensions Image.

DISCUSSION

The Effect of Plasma Treatment on Shear Bond Strength:

Based on the result obtained in the present study, as showed in table (2), oxygen plasma treatment increases the shear bond strength of both soft liner (acrylic and silicone), soft liner after immersion in distilled water for 30 days as compared with the control group (without oxygen plasma treatment) this can be attributed to etching process produce by oxygen plasma that led to enhance the surface roughness which increased the effective surface area of the high impact acrylic which led to high shear bond strength between soft liner and high impact acrylic resin, these results were in agreement with the finding of Yasuda [17] where they found that increased in the tensile bond strength between heat cure acrylic resin and two types of soft liners (silicone, acrylic) by enhancement of roughening that led to more molecular intimated contact between plasma exposed polymer surface and applied soft liner and the decrease in the mean of the shear bond strength of the silicone and acrylic soft liner after immersion in denture cleanser for 30 days may be attributed to the water uptake by this material which was dependent on the water soluble components and (like the plasticizer)/or hydrophilicity of the matrix and after immersion in denture cleanser, this led to loss of these component and finally loss of bonding, this was in agree with Mansoor [18] who found that after immersion of Ufi gel (silicon-based cold cure) soft liner in citric acid denture cleanser showed a higher solubility value (higher loss of soluble components in citric acid) which in turn lead to more water uptake.

The result revealed as shown in table (3) that the shear bond strength of Mollosil- silicone soft liner of the study group after immersion in distilled water and denture cleanser for 30 days was a statistically increased (non significant differences) this may be due to the roughening effect of plasma surface treatment which enhanced the bond strength and this was in agreement with Craig and Gibbson [19] who reported that (the adhesive effect obtained with rough surface were approximately double those of smooth surfaces), while for the control group there was a statistically decreased (high significant differences) after immersed in distilled water for 30 days and this may be due to water uptake and led to loss of soluble component, this was in agreement with Hachim [14] who found that there was a statistically decreased (significant differences) in the shear bond strength of cold cure silicone soft liner (Ufi gel) after storage in distilled water for (1and 3 month), these results disagreed with Craig [20] who suggested that storage in water did not affected the bonding strength of denture liners to acrylic denture base. These differences in results may be due to the use of high impact acrylic instead of heat cure acrylic (conventional) as well as due to the difference in the type storage solution and time of storage used in the present study.

Mollosil- Silicone Soft Liner:

There was a statistically decreased (non-significant differences) of the study group after immersion in denture cleanser for 30 days. This may be due to the chemical and physical properties of the denture base resin as well as the type of soft lining materials (silicone and acrylic) which have been led to loss of their component and loss of bonding, this was agreed with the study of Mese [21] who reported that after comparison between water and denture cleanser

(polident) immersion of both types of soft liners (acrylic and silicone) the bond strength was a statistically (non significant differences) and this may be due to the effect of difference in both adhesion properties of resilient lining material which in turn depended on physical properties, chemical properties, the type of bonding used and mode of polymerization of the soft lining material while for the control group there was a statistically increased (high significant differences) in the shear bond strength after immersion in denture cleanser for 30 days, this may be due to the fact that the chemical composition of it contained cross linking agent instead of plasticizer (like in acrylic soft liner) which led to less water uptake and became more stable when it immersed in water or other solution. The result was in agreement with Segundo et,al.,[22] who found that (the denture cleanser solution (corega tablets) did not contain any chemical component that affects the dissolution of the tested materials (acrylic and silicone soft lining materials)).

Refit- Acrylic Soft liner:

There was a statistically increased (high significant differences) for the shear bond strength after immersion in distilled water for 30 days for the study group, and this can be attributed to the oxygen plasma etching process that led to increase the surface area and enhanced the bond by mechanical interlock. This result was in agreement with the finding of Inagaki [23] who revealed that when the polymer was exposed to plasma of inorganic gases such as (oxygen, helium, argon, hydrogen and nitrogen) this led to etching reaction, radical generation and implantation of atoms.

For the control group, there was a statistically decreased (high significant differences) after immersion in distilled water for 30 days, this was in agreement with Madan and Datta, Graham et,al., and Gracia et al [24-26] who reported that when acrylic soft lining material immersed in water, two processes are feasible: the leaching out of plasticizer, other soluble component into water and the polymer absorbs the water with time led to change in mechanical and physical properties of soft lining materials (loss of resiliency and change in viscoelastic properties) so they became hard, brittle and loss their bond strength properties.

Refit-Acrylic Soft Liner:

There was a statistically decreased high significant differences after immersion in denture cleanser for 30 days for the study group and this can be attributed to the effect of the denture cleanser on the shear bond strength that led to loss of soluble component and hardening of the material that led to loss of bonding, the result was in agreement with Abdul-Razaq et,al., [27] whose study revealed that there were a statistically decrease (high differences) in tensile bond strength values between the specimens which were stored in Pepsi. This may be due to hydrolysis effect of (Pepsi) on the tensile bond strength of soft lining material with the denture base which led to air entrapment at the bond interface.

While for the control group, there was a statistically increased (high significant differences) after immersion in denture cleanser for 30 days and this can be attributed to the type of chemical composition and compatibility between the soft liners and denture cleanser. This was in agreement with Garcia et,al.,[26] who reported that when acrylic soft lining material immersed in denture cleanser (pilodent and water), the bond strength showed a statistically increase (high significant differences).

Table (4) showed that the shear bond strength between the two types of soft liner after immersion in distilled for 30 days of the study group was a statistically increased (high significant differences). This may be attributed to the effect of chemical etching of plasma that led to an increase in surface roughness and because these materials were (cold-cured) mixed and loaded by hand and allowed to set by application of weight (200 g) leading to an increase in the flow of these material into these irregularities and improved the bond strength, this was in agreement also with Polyzois [28] where he stated that rough surfaces of acrylic resin could give better bond strength than smooth surfaces.

The shear bond strength was a statistically decreased (non significant differences) after immersion in denture cleanser for 30 days, this may be due to the differences in the chemical composition of the two soft lining material therefor they have different behaviors in denture cleanser, the result was in agreement with Abdul-Razaq [12] who found that there were a non-significant differences in the mean values of (hardness and shear bond strength) of Mollosil and Viscogel after immersion in Disinfectant solutions (Solo and Chlorhexidine). Although the materials used in the present study were not the same. The shear bond strength between the two types of soft liner after immersion in distilled for 30 days for the control group was a statistically decreased (high significant differences) as in Table (4).

The results were in agreement with the study of Mese and Guzle [29] who found that after immersion of both (silicone and acrylic) soft liner of both types (heat-cured and cold-cured) in water showed decreased significant difference in the mean of tensile bond strength and hardness. This may be attributed to the effect of humid environment that led to loss of soluble component and water uptake by the soft liners which led to deterioration of physical and functional properties like hardness and bond strength

The result revealed in Table (4) of the shear bond strength between the two types of materials was a statistically increased (high significant differences) after immersed in denture cleanser for 30 days. This may be attributed to the differences in the polymerization between the soft lining material and heat cure high impact acrylic and to the effect of denture cleanser on the shear bond strength This findings were in agree with Kazanji and Watkinson [30] who found that soft lining material can absorb water or loss soluble component based on their structure and the chemical solution in which were soaked.

The Effect of Plasma Treatment on Physical Surface Morphology:

The result as shown in figures (7,8) was agree with the finding of Cvelbar [31], this difference in the appearance of the two specimens attributed to the etching process by oxygen plasma treatment causes an increase in surface area of polymer by removal of surface material and producing a rough surface (formation of pits and protuberance) and because of the process of etching and production of rough surface will contribute in more intimate contact between soft lining materials (acrylic and silicon) and high impact acrylic denture base which in turn resulting in further bonding strengthening.

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