Effect of The CO_2 Laser as Surface Treatment on The Bond Strength of Heat Cured Soft Liner to The High Impact Acrylic Denture Base Material

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ABSRTACT

Background: Soft liner material is become important in dental prosthetic treatment. They are applied to the surface of the dentures to achieve more equal force distribution , reduce localized pressure and improve denture retention by engaging undercut . So the aim of the study is to evaluate the effect of different surface treatment by air-abrasion AL_2O_3 and laser treatment with CO_2 laser on improving the shear bond strength of the denture liner to acrylic denture base material .

Materials and methods: the 30 specimens of heat cured acrylic denture base material (high Impact acrylic)and heat cured soft liner (Vertex ,Nether Lands)were prepared for this study .They were designed and divided according to type of the surface treatment 10 specimens for each group and as follows :Group I without any treatment (control group), Group II was treated with air-abrasion (AL_2O_3). While group III was treated with CO_2 laser which has continuous pulses with wave length(10.6) micro-meter for (15) seconds .

Results: The results revealed that lowest mean values in shear bond strength the specimens treated with AL_2O_3 (0.498 N/mm2)and control group (0.569 N/mm2)and the highest mean values for the specimens treated with CO_2 laser (0.648 N/mm2) .

Conclusion: within the limitation of this study ,CO_2 laser surface treatment of the heat cure acrylic denture resin with soft liner material resulted in highly significantly increased in shear bond strength values than control and AL_2O_3 .

Key words: CO_2 laser , AL_2O_3, Soft liner material ,Heat cure acrylic, Shear bond strength . **(J Bagh Coll Dentistry 2017; 29(1):20-26)**

INTRODUCTION

Polymethyl methacrylate (PMMA) polymers have been referred as conventional base materials and one of the most widely used denture base material with numerous advantages[1]. In addition to the denture lining material have become important in dental prosthetic treatment because they are applied to the surface of the dentures to achieve more equal force distribution, reduce localized pressure, and improve denture retention by engaging undercuts[2]**.** Therefore, more laboratory time and extra costs are needed to construct dentures with permanent lining material related to the equipment and materials used, so an adequate bond between the denture base and lining material is necessary[3].The adhesion to polymeric materials usually requires some surface pretreatments to improve wett-ability characteristics of these materials[4]**.** Several studies have investigated different methods to improve bond strength between liners and acrylic denture base material ,some these studies investigated the effect of roughening by airborne –particle abrasion on the bond strength of the soft liner to acrylic resins [5] other studies were investigated the use of chemicals, including acrylic resin monomers[6] and their combination on the bond strength of soft liners with denture resins[7]**.** However controversial results have been reported. Despite the studies reporting that an improvement of interface strength was achieved by making the surface denture base roughness prior to the application of lining material[4],others have not shown any negative effect on the roughening process of the bonding two materials[8]**.**

Progress in laser technology has show a quick adoption for being used by many in the field of dentistry due to the development of the first working laser by Maiman in 1960[9]**.**Recently, laser has been found to effective in alteration the surface of materials[4]**.** In spite of the high frequency of denture fractures, little information is available about the effects of surface treatments on the repaired prostheses. Therefore this study was designed to evaluate the effect of various surface treatments: air-abrasion with Al_2O_3 particles and CO_2 laser surface treatment on improving the shear bond strength of heat-cured soft lining material to the heat-cured acrylic resin denture base material.

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MATERIALS AND METHODS

The 30 specimens were prepared from heat cured denture base resin for this study. The specimens were divided into 3 groups according to the type of surface treatment (10 specimens for each group):

Group I: the specimens without any treatment (control)

Group II: the specimens with sand blast with Al_2O_3 (250 µm).

Group III: the specimens with CO_2 laser treatment.

Each specimen consists of two heat cured acrylic blocks made from High impact acrylic (Vertex, Vertex-Dental, Netherlands) and intermediate soft liner material (Vertex™ Soft, Netherlands) (Figure 1). Each acrylic block prepared with dimension shown in (Figure 2). Block of acrylic are placed one above the other leaving a space between them of dimension (25.4 mm 25.4mm 3 mm length, width and depth respectively). The thickness of the handle of acrylic of specimen was 13m [(10)].

Figure 1 : Heat Cure acrylic material and soft

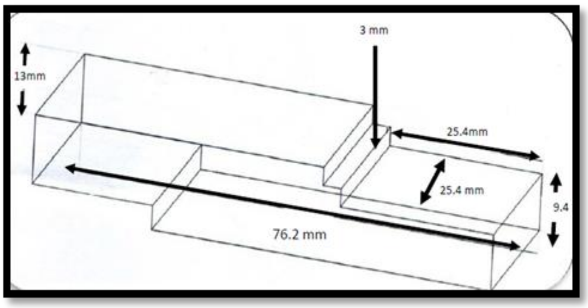

Figure 2: Dimension of shear bond strength

Specimens preparation:

The mould prepared by placement the pattern, that was coated with separating medium , into the lower half of the flask that was filled with the stone mixture after setting of the stoned, the stone and patterns were coated with separating medium and the upper half of the flask was positioned on the top of the lower half of the flask and filled with stone. The flask left to set. After an hour the flask was opened and the standard specimen was drawn out. The heat cure acrylic specimen made by mixing of the acrylic powder and liquid according to the manufacturer's instruction. P/L ratio(22g of powder / 10 ml of the liquid).The packing of heat cure acrylic was performed while the acrylic was in dough stage, as recommended by ADA specification No.12 (1999)[(11)]. The acrylic resin was removed from its mixing vessel and rolled; it was packed into the mould which previously has been coated with separating medium. The upper half of the flask was positioned in its place, then the flask was placed under hydraulic press with slow application of pressure to allow even flow of acrylic dough, then the flask was opened and by the use of a sharp knife the excess acrylic material was removed then the flask was tightly closed and clamped for curing .The curing of the heat cure acrylic according to the manufacturing instruction the flask immersed into cold water and then increased the temperature to 70ºC for 60 minutes. After that the temperature was increased to reach 100ºC for the next 60 minutes. The total polymerization time took 2 hours. Then after cooling the flask was opened and the acrylic specimen was removed.

The specimen was finished by removing all the accesses and flashes of acrylic specimens with an acrylic bur and stone bur followed by using sand paper with continuous water cooling. Polishing was accomplished for all the surfaces of the acrylic specimen except the surface that faces the reline material by using bristle brush and pumice with lathe polishing machine [(12)]. After which the acrylic specimen were measured using digital verneir (with an accuracy of 0.01) to end up with approximately dimensions (Figure 3). Then the acrylic specimens were conditioned in distilled water at 37ºC for 24 hours according to ADA specification No.12 (1999).Any porous specimen was discarded form the specimens that collected for the purpose of the study.

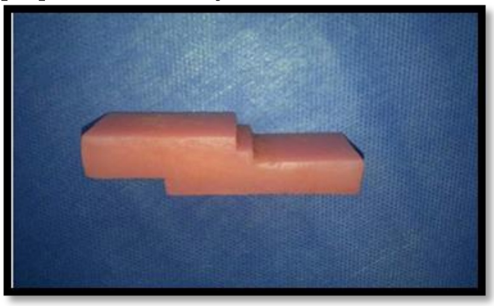

Figure 3: An acrylic block of the shear bond strength specimen.

The surface treatment:

The specimens were treated by CO_2 laser to ensure an equal distribution of the CO_2 laser treatment on the entire surface bonding area of each acrylic block and to standardize the laser treatment for all acrylic blocks a method was created as follow:

An aluminum plate was cut (equal to dimensions of the acrylic block bonding surface area). Then the aluminum plate was perforated with a special turning machine. This has the ability to drill small perforations that are equal in diameter and equal in distance from each other. The perforations diameter was of 2mm which is suitable for the laser to pass through them. 5-6mm distance was chosen between each two perforations (the smallest distance that machine can provide and under control without distorting the aluminum plate) (Figure 4).

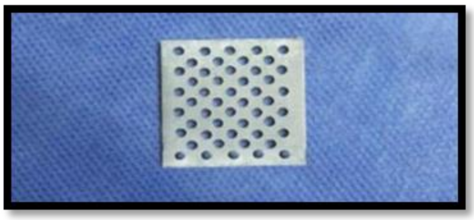

Figure 4: The aluminum plate for standardization of CO_2 laser treatment.

The laser device (CO_2 laser, China)(Figure 5)is the therapy laser, which is a solid state pulsed CO_2 laser emitting radiation at wavelength of 10.6 nm in the infrared region of the electromagnetic spectrum, and classified as a class IV laser according to the (ANSI) classification and is supplied with its protective eye-wears. A fixed distance was created by stabilizing the exit window of the laser hand piece and the aluminum plate. The distance chosen for this purpose is (63 mm) according to the manufacturer instruction of CO_2 laser device for each hole and standard distance in laser application for each acrylic blocks.

The laser treatment application was made under supervision of a laser specialist at the laser institute in Baghdad University. After wearing eye glass for protection, the metal plate was put on the bonding surface of the acrylic block and the laser treatment was carried on by holding the laser hand piece vertically and at a fixed distance from the aluminum plate the exposure time was (15 seconds) for each hole in the metal plate (figure 6) [13].

Figure 5 : The CO_2 Laser

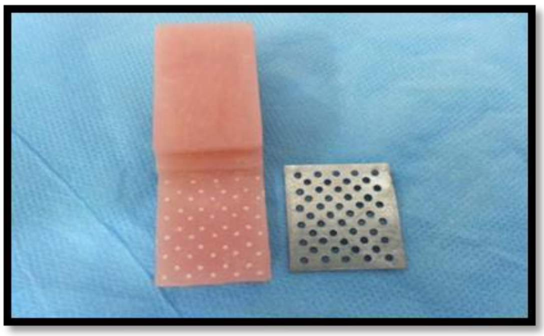

Figure 6:The surface treated acrylic specimens with CO_2 laser

The acrylic blocks was stored in distilled water for 24 h and ready for soft liner application [12].

The specimens for Al_2O_3 treatment were sand blast by using laboratory air abrasive blaster with Al_2O_3 at air pressure of 4bars for one min. The specimens were held with special design fixture for standardization of distance between the specimen surface and nozzle of device 20mm[14] .

After complete dryness of the acrylic specimens from distilled water. The soft liner was applied. The vertex soft lining material is supplied as powder& liquid, the material was placed into the mould, according to manufacturer's instruction, the mould was pressed with the hydraulic press for 10 minute then the flask was removed; put it into the clamp and then into thermostatically controlled water bath to polymerize, cold water heated slowly up to 100ºC for 0ne and half hours, then the clamp was removed; allowed to cool slowly before opening it; after opening the excess was cut with sharp knife then the specimen was removed from the mould .

Shear bond strength testing procedure:

Universal testing machine to test shear bond strength was used. The specimen was fixed to the machine using suitable clamps and subjected to 1000 N load at cross heat speed 1mm /min. until failure was occurred[15] (Figure 7). The maximum force at failure of the specimen was recorded in Newton in order to calculate the shear bond strength value for each specimen according the following formula:

SBS=F/SA (ASTM Spec.D-638m,1986) [16]

SBS: Shear bond strength (N/mm^2)
F: force of failure (N)
SA: surface area of bonded site (mm^2)

mean values for the specimens treated with AL_2O_3 and the highest mean values for the specimens treated with CO_2 laser as shown in (Table 1), and (Figure 8).

Statistical analysis
The data was statistically analyzed with the computer program Statistical Package for Social Sciences (SPSS) version 21.0 for Windows. The means and standard deviations were obtained. Also, the one-way analysis of variance (ANOVA), and multiple comparison tests utilizing the least significant difference test (LSD) were used for comparison of the effect of different surface treatment on the shear bond strength of heat cured acrylic specimens. A 95% confidence levels were used.

Effect of the different surface treatment:
In comparison of means values of the shear bond strength of the soft liner to the heat cured acrylic the ANOVA-test was showed there were highly significant different between the tested groups as shown in (Table 2).
The LSD test between groups of shear bond strength test showed there was reduced significantly in the shear bond strength between the control group and specimens treated with AL_2O_3 and a highly significant increased between the control group and specimens treated with CO_2 laser, as well as there was a highly significant difference between groups of treatment with AL_2O_3 and CO_2 laser as shown in (Table 3).

Table 1: Descriptive of shear bond strength value.

	Mean	SD	SE	Min.	Max.
Group I (control)	0.569	0.03071	0.00972	0.53	0.61
Group II (AL_2O_3)	0.498	0.02251	0.00712	0.47	0.53
Group III (Laser)	0.648	0.09496	0.03005	0.53	0.78

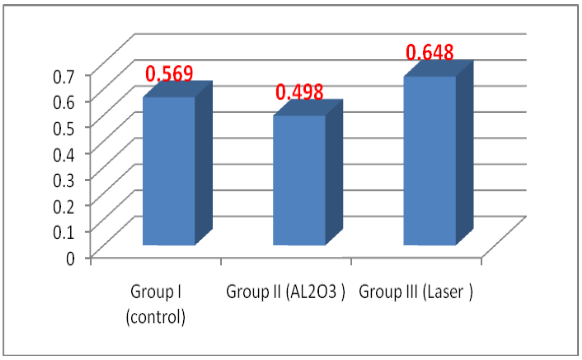

Figure 8: the shear bond strength of the soft liner in all groups.

Table 2: ANOVA of shear bond strength between groups of the soft liner according to different surface treatment.

	Sum of Squares	DF	Mean Square	F-test	P-value
Between groups	0.113	2	0.056	16.136	0.000
Within Groups	0.094	27	0.003		
Total	0.207	29			

*P<0.01 High significant

Table 3: LSD test between the groups of different surface treatment.

	Mean Difference	P-value	Sig
Group I (control) & Group II (AL_2O_3)	0.071	0.012	S*
Group I (control) & Group III (CO_2Laser)	0.079	0.006	HS**
Group II (AL_2O_3) & Group III (CO_2Laser)	0.150	0.000	HS**

*P<0.05 Significant
** P<0.01 High significant

DISCUSSION

Only few studies have been conducted on the laser treatment of acrylic resin surfaces. Lasing had been used to alter the surface of the PMMA with the intention of providing increased surface area and mechanical locks. This in turn should benefit the bond sites resulting in a stronger bond[17]. In general laser can provide an easy, safe, clean and time saving surface treatment that results in suitable surface pits and roughness which in turn increase soft liner bonding.

Shear bond strength are suitable for examining the bond strength of soft liner to acrylic, as the masticatory forces in the oral cavity are approximately similar to tear and shear forces rather than tensile forces [18].

Several problems were associated with the use of resilient denture liners, including bond failure between the liner and denture base, porosity of the resilient lining material, and loss of softness of lining material, colonization by *Candida albicans* in addition to poor tear strength, although limitations exist in the areas of clean ability, hardness, volumetric change due to water absorption, and abrasion resistance, never the less bonding properties of the resilient lining material should be evaluated throughout one of the available several investigation shear, tensile, peel bond strength tests[2,19] .

For the effect of different surface treatment on the shear bond the results of this study showed there were highly significant differences between the control group and different surface treatment with AL_2O_3 and CO_2 laser treatment.In the present study, it was found that sandblasting of the PMMA surface with AL_2O_3 before application of soft liner resulted in a significant decrease in the bond strength when compared with control group this result agreed with Amin et al [20] ,Jacobsen et al. [17], and Akin et al.[21] they reported that roughening the acrylic resin base by sandblasting before applying a lining material had a weakening effect on the bond. Also agreed with another study that was showed the surface roughness was reduced the shear bond strength[22],but this result was contradicted those of Usumez et al.[4] who found that alumina abrasion of the PMMA before resilient-material application resulted in higher mean bond strength than those of control specimens. This could be attributed to the micro-pitting produced an elevation and depression at the surface of denture base material so the peaks of elevation act as a stress points to weaken the bond interface, as well as the rough surface decreased the surface tension which consequently affects the interface adhesion[22].

For the comparison of surface treatment with CO_2 laser with control the results of this study showed there were highly significant increase in the shear bond strength. This could have been explained as follows: The impact of the high energy pulse of CO_2 laser may had caused an instant vaporization of water from the heat cured acrylic resin and this could in turn result in a massive volumetric expansion. This expansion in turn could have caused the surrounding material to ablate and thus increasing the surface area of the treated acrylic through producing surface roughness[23].Therefore, soft-lining materials penetrate into the irregularities or pits produced by the CO_2 laser and increase the strength of the bond [21]. So theoretically, both manipulations (increased surface area and mechanical locks) should benefit the bond site and result in stronger bonds [17]. Another cause could be attributed to the fact that the laser surface treatment of the heat cure acrylic resin did not affect or change the chemical bonding of active sites of acrylic based soft liner surface[24]. This agreed with Al-Athel and Jagger in (1996)[18], Polyzois and Frangou in (2001)[25], and Mese et al. in (2005)[26] they explained that a chemical bond had been formed between the acrylic based soft liner and PMMA denture base polymer by a similar chemical composition. Therefore, the surface of heat cured acrylic that was treated with the laser application could have resulted in irregularities with a lots of pits on the surface of the denture base resin, this in turn could have led to a conclusion that a soft lining material can penetrate into the irregularities and pits produced by CO_2 laser so that increase the strength of the bond.

For the comparison of the effect of surface treatment with AL_2O_3 and CO_2 laser groups the results showed there was highly significant difference between the CO_2 laser group in comparison to AL_2O_3 group this could be attributed to that the size of irregularities created by the sandblasting medium may be insufficient to allow flow of the resilient lining material into them [17] in comparison to the size of the irregularities or pits produced by the CO_2 laser was quite sufficient to allow the flow of the soft liner, here the viscosity of the acrylic based soft liner could have enabled it to penetrate into the regularities of the bonding surface. This could be proved theoretically by the fact that the penetration coefficient is inversely proportioned to the viscosity[24].

With the limitation of this study, we concluded there was significantly highly increased in the shear bond strength values for the specimens treated with CO_2 laser and lowest mean values that treated with AL_2O_3 when compared with the control group.

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