Comparing Shear Bond Strength Of Auto-polymerized Soft Lining Materials to Acrylic Denture Base Using Different Surface Treatment and Denture Base Materials.

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ABSTRACT:
Background: Denture bearing tissue condition may be highly affected by stress applied from the occlusal force during function of mastication therefore the need for denture soft lining material application is necessary and testing the bond strength of this material to acrylic denture base is of some point of interest and need to be improved. The aim of the study is to test the shear bond strength of soft lining materials to the denture base after surface modifications and using different denture base materials.
Materials and Methods: 120 samples included in the study to test the shear bond strength, sample grouped according to surface treatment of acrylic resin (Control without surface treatment, monomer surface treatment, Nd-Yag laser surface treatment (10 Hz and 20 Watt) and Nd-Yag laser surface treatment (10 Hz and 40 Watt)) with different denture base materials used (High impact acrylic, Heat cured acrylic and light cured acrylic), the shear bond strength test was made by using universal testing machine with cross head speed 40 mm/ min the force required for soft lining material complete separation from the acrylic resin materials calculated. Statistical analysis made by SPSS software analysis using ANOVA Table with LSD multiple Comparison.
Results: the highest value of shear bond strength found in group with high impact acrylic and 2nd dose of laser treatment applied, while the lowest one found In a group of light cured acrylic when 1st dose of laser treatment used. the comparison among groups made by using ANOVA Table with LSD which revealed that there was a highly significant difference between all groups with different surface treatments except heat cured and light cured groups. A highly significant difference also found between 2nd dose of laser treatment and control, monomer and 1st dose of laser surface treatment when different materials used.
Conclusion: 2nd dose of laser surface treatment when 10 Hz and 40 Watt of Nd-Yag Laser applied Show the highest value of shear bond strength in high impact acrylic group, while the lowest value was recorded in light cured acrylic with 1st does laser treatment.

KEYWORDS:
Soft lining materials, denture base, Laser, Monomer. High impact acrylic, light cured acrylic.

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مقارنة قوة القص السطحي لالتصاق البطانة اللينة مع مادة قاعدة أطقم الاسنان بعد معالجة سطحها بمواد مختلفة

لتحسين التصاق مادة بطانة أطقم الاسنان مع قاعدة الطقم تم استخدام عدة طرق لمعالجة سطح مادة أطقم الاسنان قبل وضع البطانة المرنة واستخدمت ١٢٠ عينه لهذا الغرض توزعت حسب المادة المستعملة في معاملة أسطح مادة طقم الاسنان الاكريليكية وتم ايضا استخدام مواد مختلفة من مادة أطقم الاسنان وتبين بعد الفحص بواسطة قوة القص السطحي ان معاملة السطح بال Nd-YAG ليزر (١٠Hz و٤٠ watt) نتجت عنها اعلى قوة التصاق عند استخدام الأكريليك الحراري المقاوم للصدمة، بينما كانت اقل قوة التصاق في المجموعة التي عوملت بال Nd-YAG ليزر (١٠ Hz، ٢٠watt) باستخدام الأكريليك المتصلب بالضوء

INTRODUCTION:

Although soft lining material was first used in 1961 widely in partial and complete dentures [1], and should fulfill a list of requirements, but above of all it should bond in a satisfactory way with acrylic denture base; otherwise problems will arise like plaque accumulation, bacterial growth..etc [2-4].

So many researchers suggested different methods for improving bond between soft liners and acrylic denture base like mechanical roughening by laser, monomer, or by sandblasting [5-7].

Laser is an intense beam of light energy, it was first developed by Mainman in 1960, in its early invention laser was a technical breakthrough, but was a technology rather than purpose [8].

Laser gets the approval from the FDA and was introduced to dentistry about 35 years ago, and since that, researches continues to expand in this field [9], it becomes more common for caries removal, root canal treatment, remove periodontal disease, bleaching, disinfecting.

Laser light has the advantage of interacting with biological tissue because of its particular properties: (1) monochromaticity i.e. one color (2) coherence like waves have identical amplitude and frequency (3) collimation like laser rays are parallel and don't diverge (4) brightness [10].

There are many types of lasers such as ruby laser, He-Ne laser, Nd-YAG laser, Co2 laser, and Er-YAG laser, in this study Nd-YAG laser used, it was first used in 1990, and it is near the infrared wavelength of 1064 nm. It works on contact and non-contact way, which both can be used depending on performed procedure [11].

Because laser have the capacity to alter surface of material in a relatively easy and safe way [12], it can be used to increase bonding between materials and make benefit to solve the drawback of soft liner and denture base.

The use of laser in these studies are still limited so the present study try to make a comparison between monomer and laser application using different denture base materials and find out what will come with best result to overcome the dilemma of soft liner detachment from acrylic denture base.

MATERIALS AND METHODS:

Sample Grouping:

120 samples were constructed, divided according to materials' used: (high impact/ Vertex), (heat cure, Triplex) and (light cure, Vertex LC), each group was further subdivided according to surface treatments; so that the total number of groups included in the study were twelve groups and they were summarized as follows:

a. Control without surface treatments (Heat Cured Acrylic)
b. Control without surface treatments (High impact Acrylic)
c. Control without surface treatments (Light Cured Acrylic)
d. Monomer surface treatment (Heat Cured Acrylic)
e. Monomer surface treatment (High impact Acrylic)
f. Monomer surface treatment (Light Cured Acrylic)
g. Laser surface treatment 10 Hz 20 Watt (Heat Cured Acrylic)
h. Laser surface treatment 10 Hz 20 Watt (High impact Acrylic)
i. Laser surface treatment 10 Hz 20 Watt (Light Cured Acrylic)
j. Laser surface treatment 10 Hz 40 Watt (Heat Cured Acrylic)
k. Laser surface treatment 10 Hz 40 Watt (High impact Acrylic)
l. Laser surface treatment 10 Hz 40 Watt (Light Cured Acrylic)

Sample preparation:

High impact and heat cured acrylic samples:-

A metal mold used for shear bond strength sample construction, it measured (75mm, 25mm, 5mm) length, width and height respectively, with 3mm depth and handle thickness of 13mm [13] to have a maximum clamping of samples with instron machine (Fig. 1).

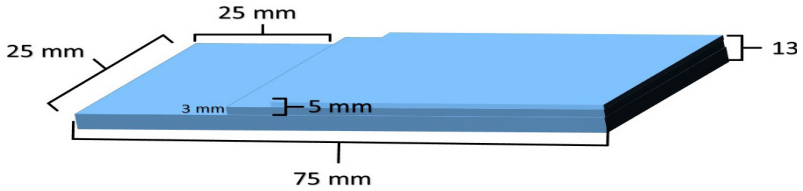

Fig. 1. Shear Bond Strength Specimen.

The samples constructions for high impact acrylic denture base materials were done by mixing of powder and liquid according to manufacturer's instruction (P/L ratio 21g/10ml) then a layer of separating media applied to the stone mold made from the metal templates and the dough acrylic mixture adapted to the stone mold, cured in water bath at 70 °C for 90 minutes, followed by 100 °C for 30 min. according to manufacturer's instructions, then allowed for bench cooling. The same procedure undertaken for heat cured except curing cycle which run under 70 °C for half an hour followed by 100 °C for one hour according to manufacturer's instructions.

Light cure samples:

The material was packed in stone mold after application of separating media, pressed with fingers, then cured by light curing unit (Vertex Ecoligth box/ Holland) initially for 5 min and removed from the mold and cured again for 5 min. The excess materials removed with sharp wax knife before curing.

Surface treatment:

a. Monomer Surface treatment: Samples were swabbed with a cotton dipped in monomer for 180 sec before soft liner application.
b. Laser surface treatment: Nd-Yag laser was used to treat the surface of the acrylic which will bond to soft liner materials, the wavelength fixed to (1064 nm), and the frequency fixed to 10 Hz., while the power set to 20 and to 40 watt. The surface of the acrylic block divided into four lines, the distance between line and the other fixed to 6.35 mm, each line divided into five parts equally and the laser

strokes applied to these five points on each line, so that the total strokes applied to each specimen will be 20 strokes. The exposure time for each point will be set to 4 sec. The distance between the head of the laser device and the surface of the specimen fixed to 12 mm by using plastic cable tie [16].

Application of soft liner material to the samples:

The soft lining material (mollosil/ chair side / Germany) was applied in the space between the two blocks of shear bond strength, one over the other in a space dimension of 25mm, 25mm, 3mm (length, width and depth respectively); the reline material mixture applied by using spatula, the excess material was removed by sharp wax knife then samples placed under 200 g of load until complete set of material.

Testing the samples:

Testing was done by using Instron testing machine, the cross head speed 40 mm/ min. and the soft lining material was separated from the acrylic plates [18]. The force required for this separation was calculated, the shear bond strength value of each sample was calculated by applying the following equation:

Shear Bond strength=F(N)/A (mm^2) [19].

F=force of failure (N).

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

The data was analyzed by SPSS v. 21 statistical analysis software using ANOVA Table with LSD multiple comparison test.

RESULTS

As shown in Table 1, the highest mean of shear bond strength found in the group of high impact acrylic and when 2nd dose of laser surface treatment applied, while the lowest value found in the group of light cured when 1st dose of laser surface treatment applied.

Table 1: Descriptive Statistics for all groups.

	N	Control		Monomer Surface Treatment		1st Dose of Laser Treatment		2nd Dose of Laser treatment	
		Mean (N/mm^2)	SD	Mean (N/mm^2)	SD	Mean (N/mm^2)	SD	Mean (N/mm^2)	SD
Heat Cured	10	0.747	0.029	0.756	0.018	0.746	0.037	0.838	0.023
High impact	10	0.863	0.024	0.840	0.041	0.849	0.032	0.921	0.015
Light Cured	10	0.745	0.036	0.765	0.012	0.740	0.037	0.856	0.019

Inferential statistical analysis done by using ANOVA Table with LSD to compare both materials used in the study and different surface treatment of these materials, the results revealed that when comparing materials used in the study there is highly significance among all groups except when comparing heat cured and light cured materials using different surface treatments as shown in Table 2 and 3.

When comparing surface treatment of different materials used in the study, the results show that there are highly significant difference between Control group and 2nd dose, Monomer and 2nd dose, and 1st dose and 2nd dose of laser surface treatment, while other groups comparisons show no significant differences as shown in table 4 and 5.

Table 2: ANOVA Table comparison for groups categorized according to method used for surface treatments.

		Sum of Squares	df	Mean Square	F	Sig.
Control (Without Surface Treatment)	Between Groups	0.091	2	0.045	49.234	H.S.
	Within Groups	0.025	27	0.001		
	Total	0.116	29			
Monomer Surface Treatment	Between Groups	0.042	2	0.021	28.379	H.S.
	Within Groups	0.020	27	0.001		
	Total	0.062	29			
1st Dose of Laser Treatment	Between Groups	0.074	2	0.037	28.857	H.S.
	Within Groups	0.035	27	0.001		
	Total	0.109	29			
2nd Dose of Laser treatment	Between Groups	0.038	2	0.019	47.732	H.S.
	Within Groups	0.011	27	0.000		
	Total	0.049	29			

Table 3: Multiple comparison Post hoc LSD test according to method used for surface treatments.

	Control		Monomer		1st Dose		2nd Dose	
	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig
High impact- Heat Cured	0.1158	H.S.	0.0838	H.S.	0.1023	H.S.	0.0829	H.S.
High Impact-Light Cured	0.1175	H.S.	0.0744	H.S.	0.1086	H.S.	0.0651	H.S.
Heat Cured – Light Cured	0.0017	0.901	-0.0094	.447	0.0063	0.698	-0.0178	.057

Table 4: ANOVA Table comparison for groups categorized according to material used

		Sum of Squares	df	Mean Square	F	Sig.
High Impact	Between Groups	0.040	3	0.013	14.685	H.S.
	Within Groups	0.033	36	0.001		
	Total	0.073	39			
Heat Cured	Between Groups	0.059	3	0.020	24.973	H.S.
	Within Groups	0.028	36	0.001		
	Total	0.088	39			
Light Cured	Between Groups	0.087	3	0.029	35.903	H.S.
	Within Groups	0.029	36	0.001		
	Total	0.117	39			

Table 5: Multiple comparison Post hoc LSD test according to material included in the study

	High Impact		Heat Cured		Light Cured	
	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig.	Mean Difference (I-J)	Sig.
Control- Monomer	0.0232	0.094	-0.0199	0.127	-0.008	0.488
Control= 1st Dose	0.0142	0.300	0.0053	0.680	0.0007	0.956
Control- 2nd Dose	-0.0582	H.S.	-0.1106	H.S.	-0.0911	H.S.
Monomer- 1st Dose	-0.009	0.509	0.0252	0.056	0.0095	0.455
Monomer- 2nd Dose	-0.0814	H.S.	-0.0907	H.S.	-0.0823	H.S.
1st Dose- 2nd Dose	-0.0724	H.S.	-0.1159	H.S.	-0.0918	H.S.

DISCUSSION

An appropriate bond between denture base and soft lining material is a required demand, but unfortunately, all materials available are considered temporary compared to hard denture base, because it is associated with low physical and mechanical properties, it leads to bacterial and fungal aggregation, and poor bond to denture base material [20].

Many researchers have been studied different methods and test to increase this bond, but there was a controversy about the effectiveness of surface treatment like monomer application, acetone, laser, aluminum oxide, making holes through acrylic, etc.… [2,3,12], and the majority agreed with the fact that treating surface with abraded particles will decrease the bond [21].

Fowler [22] and Cantor et al [23] pointed out that, tensile failure was not only due to tensile forces but also caused by shear forces occurred because of the high Poisson's ratio of silicone soft liner. So that

testing the soft liner using shear bond test is believed to be a useful way to measure bond strength because of close simulation to clinical situations [24].

There is a limited published papers studied the effect of laser on shear bond strength of different denture base and soft lining material; this study compare the effect of laser and monomer on three different types of denture base to improve bond with soft lining material.

The present study showed that the highest mean value of shear bond strength was for high impact denture base acrylic material when compared to heat cured and light cured denture base acrylic materials, this significant difference could be explained due to the fast raising in temperature during curing as a short curing cycle used, causing the production of many new radicals leading to more growing polymer chain, and more branching and cross linking [25].

In this study, the effects of surface treatment with monomer on shear bond strength between soft liner and both heat cured and light cured acrylic were not significant despite the mean differences found, this is in agreement with Memarian and Shayestehmajd [26] who found that MMA alter the surface morphology without improving the shear bond strength, while the results disagree with Kulkarni and Parkhedkar [21] and with Sarac et al [27] who found that surface treatment of acrylic denture base with monomer increase the bond to soft lining material, this disagreements may be due to the differences in methodology of surface treatment used and materials.

The altering of surface material when exposed to laser energy is due to ablation which is removing of surface material because of energy absorption, and since the material exposed in this study is polymer so a photochemical ablation took place creating ablated regions, carrying away liquid and solid clusters of material substrate [28] .

Regarding surface treatment with Nd-Yag laser, the second dose of laser had the highest mean value compared to first dose; this may be due to the different absorption capacity of resin material [29]. Also Suke et al [30] explain a chemical change may occur on acrylic surface when exposed to laser energy which cause shortening of chain length then increasing the chain cross linking, and this is believed to ameliorate the bond between denture base material and soft lining material.

Laser energy cause more irregularities than methyl methacrylate monomer, this explains the high significant values compared to monomer and control groups; the rough surface creates a larger contact area in denture base and improve the micromechanical interlocking [31] this will affect the bond strength of denture base with soft liner in a good way [32]. this comes in agreement with Jacobson et al [33] who stated that soft lining material has the ability to penetrate to denture base irregularities which improve the adhesion, it also agrees with Al-Noori and Al-Kateb [34] who found that laser treatment is superior to monomer.

Although it is an in vitro study and does not mimic the in vivo conditions but still can give a possible estimation of clinical outcome.

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