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The Effect of Chemical Surface Treatments on Some Mechanical Properties of a Modified Auto Polymerizing Acrylic Resin as a Repaired Material

Thekra Ismael Hamad

Prosthodontic Department, College of Dentistry, University of Baghdad, Baghdad-Iraq

Abstract: ***Background**: Polymer acrylic denture bases fracture is often occurrence, due to a low flexural strength of the resin, choice of the material, properties of the acrylic resin, faulty design and method of manipulation. Repaired of fractured denture bases are mandatory because it is time- consuming and expensive to make new prostheses. **The aim of the study**: To evaluate the effect of different chemical surface treatments and the repaired surface design on the transverse and impact strength of the heat cure acrylic resin repaired with auto polymerized acrylic resin and modified auto polymerized resin with lignin. **Materials and Methods**: A standard heat polymerized acrylic resin specimens were prepared according to ADA Specification No. 12 for transverse strength, ISO 179- 1982 for impact strength and repaired with auto polymerized resin and modified auto polymerized resin with lignin after chemical surface treatment with monomer as a control group and acetone and chloroform as an experimental groups for butt and bevelled joint using Ivomet (pressure pot). A total of 200 samples were fabricated for this study.Transverse, impact and elongation were tested using Instron Universal testing device and Charpy impact machine. **Results**: Repair of the specimens with a modified cold cure acrylic resin with lignin and treated with chloroform showed the highest value of transverse and impact strength. The repaired specimens with beveled joint design have a highly significant difference than those repaired with butt joint design. The adhesive type of failure found more in a butt joint, while the beveled showed a high percentage of cohesive and mixed type. **Conclusion**: chemical treatment of repaired surface with chloroform have enhanced the transverse and impact strength of cold cure acrylic reinforced with lignin more than that treated with monomer and acetone. The type of material used, reinforcement of the acrylic resin, method of repair and design of the joint have a significant effect on the strength of the repaired denture.*

Keywords: auto polymerizing acrylic, Kraft lignin, chemical treatments

1. Introduction

Denture fracture is a major problem in prosthodontics for patients and dentist [1-8] Researchers were considered different approaches to solving the problem of dentures broken, such as by reinforcing the fractured denture fragments, using different denture repair material, modifying repair surface contours, and using different processing methods[9,10].

All denture bases were constructed from the acrylic resins (methyl methacrylate polymers or co-polymers). The clinical performance of PMMA resin is dependent upon its physical and mechanical properties. However, the poor strength characteristics including the low impact and transverse strength is a primary concern.[1,2,7,10,11,12]

The objective of denture repair is to prevent further fractures. Different materials have been used to repair fracture denture like auto polymerized [2,4,13] heat polymerized[2,4,14], microwave polymerized[14-16], and visible light polymerized acrylic resins[2,4,13,14,17], the using of auto polymerizing resin is the most popular material used for repairing fractured denture bases [18] Although repairing with auto polymerized resin is weaker than the heat- polymerized denture resin that originally used[18,19]. To improve the mechanical properties of the repaired sites many attempts have been made by changing either the processing methods[20,21], the joint surface contours[20,22], using surface treatment23,24], or reinforcing[25,26], and optimizing the distance between repaired sites[22].

The denture base material failure may involve either fatigue failure or impact failure. Fatigue failures occur during function due to continued flexing of the base, that creates crack propagation which results in midline fracture. Impact failures involve rapid stressing of the material like dropping the denture on a hard surface.[7,14,27,28]

Different methods have been suggested to strengthen acrylic resin dentures. These are include reinforcing or modifying the acrylic resin. [7,10,26]

Denture fracture is frequent despite the advantages of the acrylic resin due to impact failure and flexural fatigue [7,30,31] Enhancement of physical and mechanical properties of acrylic resin dentures by incorporation of different fibers to denture polymer resin [25,26,33.34].

The most common repaired material used to produce better strength similar to conventional heat cured resin is auto polymerized that exhibited a better repair strength than visible light cure resins[2,16,25] and microwave polymerized resins[35]. The type of joint used is one of the important factors in the strength of a repair. Many authors have suggested smooth and rough interface surfaces, 45- degree angle joints, butt joint (90◦), rounded and rabbeted joints, tapered, and joints with mechanical retention [7,36,37] Different concepts advocated to provide the best method for preparing the interface surface of the fractured denture to obtain the strongest joint strength and can prevent the recurrence of fracture [2,30].

Lignin is a biochemical polymer which functions as a structural material in plants. It is a promising compound to be used in polymers because of its phenolic base structure, which allows it to function as a binder in woody plants and make it an excellent candidate for use as aco-reactant in many different adhesive systems, which could lead to improvement of the mechanical properties when incorporated in a plastic. [38-40]. Insoluble kraft lignin in polymers included as fillers in thermoplastics [41] or as a chemical component in polyblends [38].

Graft copolymerization has been known as a useful way to improve the properties of many polymers with the goal of extending their applications [42].

The present study investigates the commonly used butt joint and 45- degree angled joint, with and without lignin with different chemical treatments on fractured surface.

The objective of the study:

- To evaluate the transverse and impact strength of heat cure acrylic specimens repaired with conventional auto polymerized resin and modified (reinforced by lignin) auto polymerized one.
- To study the effect of contours of the joint surface (design) on the transverse and impact strength of denture base resin repaired by auto polymerized resin and modified (reinforced by lignin) one.
- To evaluate the effect of using three chemical solvents (monomer, chloroform, and acetone) on transverse and impact strength of heat cure acrylic resin, when repaired with auto polymerized resin and modified one.
- To find out the type of the failure of repair as adhesive, cohesive or mixed.

2. Material and Methods

This study was carried out in the Department of Prosthodontics, the materials used in this study include: Heat cured acrylic resin powder and liquid (Major product Dentari, Italy), self-cured polymethyl methacrylate (Major product Dentari, Italy) powder and liquid, kraft lignin alkali (powder, Aldrich company), monomer, acetone, chloroform.

1) Preparation of the specimens:

Standard metal specimens were created according to ADA specification No. 12 in1999 for transverse strength and ISO 179 in 1982 was used for impact testing. The metal specimens of dimensions (65x10x2.5) mm for transverse strength and (55x10x10) mm for impact strength. Coating of the stainless steel specimens with a thin layer of petroleum jelly(vaseline) and 4 specimens were inserted into the lower portion of the flask using dental stone (Type IV)(elite stone, Zhermack) taking consideration that one- half of the thickness was implanted in the stone keeping adequate separation amongst them. Separating medium were painting on the stone surface, after setting of the stone. The upper portion of the flask was then set up and filled with dental stone with vibration to finish flasking.

The metal specimens were recovered from the stone after the opening of the flask. Hot water was used to get rid of any remnant of petroleum jelly from the molds. The acrylic resin test samples were fabricated from the prepared molds . The exposed dental stone surfaces of the two portions were painting with separating medium (cold mold seal, Dental Product India). Heat cure resin was mixed in a ceramic jar according to manufacturer’s instructions ratio of powder and liquid of the (12 gm: 6ml) and left in the mixing jar until a dough stage was reached. The dough was then packed into the mold, and final closure was done under a bench hydraulic press at 40,000 N (KaVo EWL, Leutkirch, Germany). The flask was immersed in water bath in an acrylizer with automatic controls (KaVo EWL) for curing of heat acrylic specimens, the temperature was gradually increased from room temperature to 70ºC for 30 min., then increase to 100 ºC for other 30 min., then the flask was removed after complete curing, and left for bench cooling.

Finally deflasking & finishing the acrylic samples and kept in distilled water at room temperature for 7days.

2) Preparation of fracture samples:

A silicon carbide bur was used for the fracture of the samples at midline, removing the acrylic resin to create a 10 mm gap between the fractured specimens. The cut ends of each specimen were ground to butt joint and 45◦ bevel joints by using the central recess of a metal holding device. The wax was occupied the 10 mm gap and invested using a conventional flasking procedure, and wax elimination were done. The fractured surfaces were cleaned ultrasonically utilizing distilled water and dried up with air. The specimens were divided into 5 groups, 10 specimens for each group.

The fractured surfaces were chemically etchants by immersion in methyl methacrylate for 180 sec.[19,43], in acetone for 30 sec.[43,44], and in chloroform for 5 sec.[23,43] the specimens were returned and situated in the similar position in the prepared mold so that a 10 mm gap survived between the two parts of the specimens.

A conventional auto polymerized polymer were used by mixing of powder and liquid proportion of 12gm/6ml wt/v according to manufacturer's recommended until a dough stage was achieved and filling the gap between 2 parts of the specimen after treatment of the repaired surface with monomer, acetone, and chloroform, for butt and bevelled joint, the two portions of the metal flask closed in about 10 seconds and put below a hydraulic press with utilizing of pressure until all the excess materials get out the metal flask. Unloose of the press and instantly put the flask in (Ivomet) pressure pot in 2bar and 40°C for 30minutes [45].The same method was repeated for impact strength test specimens.

3) Synthesis of Modified PMMA Polymers

Modified PMMA polymers were synthesized by mixing of 0.5wt% of kraft lignin with methyl methacrylate (MMA)[45] for 3 minutes by a probe sonication apparatus which provides ultrasound waves result into more scattering and adequate saturation of lignin within the monomer. The powder was mixed according to manufacturer instructions (12gm/6ml wt/v) until achieving to a dough phase, manipulate immediately in the gap after treatment of the repaired surface with monomer, acetone, and chloroform for butt and beveled joint, closure of the two portions of the metal flask and put below a hydraulic press and allow the access material to exist from the flask. Immediately after liberate, placed it in (Ivomet) pressure pot in 2bar and 40°C for 30 minutes[45], this method was done for all specimens for transverse and impact strength test.

A total of 200 specimens were produced for this study, 100 specimens for each test. Each sample were milled to the correct dimensions [2.5mm ×65mm x 10mm] for transverse strength, and [55mm x10.0 x 10.0] for impact strength. Finishing and polishing of all the specimens as finishing of the dentures, rinsed with distilled water to get rid of any remaining monomer, denotation, and numbering of each specimen according to the material group, and then kept in distilled water for 48 hours at 37°C before testing.

4) Description of groups

For each type of joint (Butt-BJ- and Bevelled-VJ) 50 specimens were used in 5 groups

1. Control group (BJMC, VJMC): we used a conventional auto polymerized acrylic resin as a repaired material and treated the fractured surface with a monomer for 180 sec.
2. BJAC, VJAC: we used a conventional auto polymerized acrylic resin as repaired material and treated the fractured surface with Acetone for 30 sec.
3. BJAL, VJAL: we used an auto polymerized acrylic with 0.5% lignin as repaired material and treated the fractured surface with Acetone for 30 sec.
4. BJCC, VJCC: we used a conventional auto polymerized acrylic as repaired material and treated the fractured surface with chloroform for 5 sec.
5. BJCL, VJCL: we used an auto polymerized acrylic with 0.5% lignin as repaired material and treated the fractured surface with chloroform for 5 sec.

5) Evaluation of Transverse Test

The transverse strength test was carried out with a three - point bending test using Instron Universal testing machine (Instron UTM, Model: 5569, U.K.), the length between two parallel support was 50,the maximum load was subjected at a cross head speed of 2mm / min to the center of 10 mm repaired area for the experimental group specimens until fracture happened[2], The transverse strength was calculated utilizing the following equation: **T=3 *PL (2bd^2)$^{-1}$*** = Mpa

T=Transverse strength (N/mm^2)

P = maximum load (N)

L = distance between the support (length of the span)(mm)

b = width of the specimen (mm)

d = depth or thickness of the specimen (mm)

6) Evaluation of Impact Strength

For the impact strength test, samples were assessed using Charpy Impact Tester according to the recommendation of ISO 179. The unnotched specimen were clamped horizontally at each end and struck by swinging pendulum of 2 joules to break the specimens.Some samples showed resistance to fracture, therefore, we increased the load to 5 joules pendulum.The impact strength was calculated using the equation:

Impact strength KJ m^{-2} = (E /b x d)**x 10^3**

b= is the width of the specimen (mm).

d = is the height (depth) of the specimen (mm).

E = the impact energy (J).

The obtained data was tabulated and statistically analyzed.

7) Evaluation of Elongation

"The deformation that results from the application of a tensile force is elongation".

A property often used to give an indication of ductility or the degree of plastic deformation an alloy can undergo before the fracture is the *elongation at fracture*.

The total percentage elongation includes both the elastic elongation and plastic elongation.

The elastic modulus (E, in Mpa) was calculated by E = (P/db)/ (Dl/l), where Dl is the increase in specimen length (mm) [46].

Types of fracture:

Visual perception of fractured specimens was observed to determine the type of fracture as adhesive, cohesive or mixed.

- Adhesive fracture: where the fracture takes place at the interface between the main resin material and repair material.
- Cohesive fracture if it occurred entirely in the repair material.
- Mixed fracture where the fracture take place at both of the repair material and at the joint between the main resin material and repaired material. [43,47,48].

Statistical Analysis: - Using of (SPSS) version 16 for analyses of the data.

3. Results

1. Evaluation of transverse strength:

a) For Butt joint group

The transverse strength of the specimens that have butt joint showed that the mean transverse strength of the Group5 (BJCL) that treated with chloroform and lignin was the highest value (51.4560)Mpa, and the lowest value was observed in the control group(BJMC) which is 25.0440 Mpa. As shown in the table (1) and figure (1).

The ANOVA test revealed that there is a highly significant difference (0.000) between groups, and in multiple comparisons between the control group and each experimental group the Dunnett t-test showed a significant difference at 0.05 level between all groups except between the BJMC with BJAC group as shown in the table (2).

Table 1: Mean, Standard Deviation and ANOVA Test Results of Transverse Strength for Butt Joint with different surface treatments

Groups	*Mean*	*S.D.*	*S.E*	*Min.*	*Max.*
BJMC	25.0440	1.97941	.88522	22.86	27.36
BJAC	26.1020	1.07472	.48063	24.48	27.36
BJAL	30.7840	3.35733	1.50144	27.20	34.56
BJCC	40.2640	3.17897	1.42168	36.00	44.64
BJCL	51.4560	5.60365	2.50603	41.76	55.63
ANOVA	Sum of Squares	Df	Mean Square	F	Sig
Between Groups	2471.081	4	617.770	53.393	0.000
Within Groups	231.406	45	11.570		
Total	2702.487	49			

Table 1: Multiple Comparison of Transverse Strength (Mpa) Test Results for Butt Joint groups [Dunnett t (> control)]

(I) Sample. BJ	*(J) Sample. BJ*	*Mean Difference (I-J)*	*S. E*	*Sig.*	*95% Confidence Interval*
					Lower Bound
BJAC	BJMC	1.05800	2.15131	.607	-3.8995
BJAL	BJMC	5.74000*	2.15131	.024	.7825
BJCC	BJMC	15.22000*	2.15131	.000	10.2625
BJCL	BJMC	26.41200*	2.15131	.000	21.4545
*. The mean difference is significant at the 0.05 level.					

B. Evaluation of transverse strength for a Bevelled joint group

From table (3) it was observed that the mean transverse strength of the group5 (VJCL) that treated with chloroform and lignin was the highest value (75.6360) Mpa, while the lowest value of transverse strength was observed in the control group(VJMC) when the specimens treated with monomer is (34. 6540) Mpa.

The effect of surface treatment of three types of chemical etchant on transverse strength ANOVA test showed that there are a highly significant differences (0.000) between groups (table3), and in multiple comparisons between the control group and each experimental group the Dunnett t-test showed a highly significant differences between all groups except VJCC group showed a significant differences at 0.05 level as shown in table (4).

Table 3: Mean, Standard Deviation and ANOVA Test Results of Transverse Strength (Mpa) for Bevelled Joint with different surface treatments groups

Groups	*Mean Mpa*	*S.D*	*S.E*	*Min.*	*Max.*
VJMC	34.6540	2.17752	.97382	31.68	37.44
VJAC	49.6360	7.33311	3.27947	41.76	60.48
VJAL	48.2320	4.24534	1.89857	41.76	53.28
VJCC	43.3360	4.46010	1.99462	37.44	48.56
VJCL	75.6360	3.61099	1.61489	70.56	80.64
ANOVA	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	4699.625	4	1174.906	53.663	.000
Within Groups	437.883	45	21.894		
Total	5137.508	49			

Table 4: Multiple Comparison of Transverse Strength Test (Mpa) Results for Bevelled Joint groups [Dunnett t (> control)]

(I) Sample. VJ	*(J) Sample. VJ*	*Mean Difference (I-J)*	*S. E*	*Sig.*	*95% Confidence Interval*
					Lower Bound
VJAC	VJMC	14.98200*	2.95933	.000	8.1624
VJAL	VJMC	13.57800*	2.95933	.000	6.7584
VJCC	VJMC	8.68200*	2.95933	.014	1.8624
VJCL	VJMC	40.98200*	2.95933	.000	34.1624
*The mean difference is significant at the 0.05level.					

2. Evaluation of Impact Strength

A. For Butt joint:

The Impact strength test showed that the mean impactstrength of the group 5(BJCL) 2.9200 KJ/m2 was thehighest value, while the minimum value was observed in the control group (BJMC) 2.6600 KJ/m2 as shown in the table (5).

The effect of surface treatment of three types of chemical etchant on impactstrength ANOVA test showed that there is a no significant difference between groups (table5), and in multiple comparisons between the control group and each experimental group the Dunnett t-test showed a no significant differences between all groups except BJCL group showed a significant differences at 0.05 level as shown in table (6).

Table 5: Mean, Standard Deviation and ANOVA Test Results ofImpact strength.BJ (KJ/m2 Butt Joint with different surface treatments groups.

Groups	*Mean*	*S. D*	*S. E*	*Min.*	*Max.*
BJMC	2.6600	.42190	.18868	2.00	3.00
BJAC	2.6600	.65803	.29428	1.50	3.10
BJAL	2.3600	.68775	.30757	1.80	3.50
BJCC	2.7400	1.12383	.50259	1.50	4.50
BJCL	2.9200	.74632	.33377	2.00	4.00
ANOVA	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.818	4	.205	.352	.839
Within Groups	11.616	45	.581		
Total	12.434	49			

Table 6: Multiple Comparison of Impact Strength Test (KJ/m2)Results for Butt Joint groups

Dunnett t (>control)					
(I) Sample. BJ	(J) Sample. BJ	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
					Lower Bound
BJAC	BJMC	.00000	.48200	.800	-1.1107
BJAL	BJMC	-.30000	.48200	.940	-1.4107
BJCC	BJMC	.08000	.48200	.742	-1.0307
BJCL	BJMC	.26000	.48200	.586	-.8507

B. For Bevelled joint:

From table (7) it was observed that the mean impact strength of the group5(VJCL) that treated with chloroform and lignin was the highest value (8.2200)KJ/m2, while the lowest value of impact strength was observed in group2 (VJAC) when the specimens treated with acetone is (2.0400)KJ/m2.

Table 7: Mean, Standard Deviation and ANOVA Test Results of Impact strength.BJ(KJ/m2) Bevelled Joint with different surface treatments groups

Groups	*Mean*	*S. D.*	*S. E*	*Min.*	*Max.*
VJMC	2.4600	.69138	.30919	1.80	3.50
VJAC	2.0400	.55946	.25020	1.20	2.60
VJAL	4.6200	1.44810	.64761	3.00	6.50
VJCC	6.2400	2.02805	.90697	4.00	9.00
VJCL	8.2200	1.26372	.56515	6.50	10.00
ANOVA	Sum of Squares	Df	Mean Square	F	Sig.
Between	134.302	4	33.575	19.525	.000

Groups					
Within Groups	34.392	45	1.720		
Total	168.694	49			

The effect of surface treatment of three types of chemical etchant on impact strength ANOVA test exhibited that there are a highly significant differences(0.000) between groups as shown in table(7) , and multiple comparisons between the control group and each experimental group the Dunnett t-test showed a highly significant differences between control groups1(VJMC) and group 4 (VJCC) and 5 (VJCL) , While group3(VJAL) showed a significant differences and the 2nd group (VJAC) revealed no significant differences at 0.05 level with the control group as shown in table (8).

Table 8: Multiple Comparison of Impact Strength Test (KJ/m2)Results for Bevelled Joint groups

Dunnett t (>control)					
(I) Sample. VJ	(J) Sample. VJ	Mean Difference (I-J)	S. E	Sig.	95% Confidence Interval
					Lower Bound
VJAC	VJMC	-.42000	.82936	.923	-2.3312
VJAL	VJMC	2.16000*	.82936	.028	.2488
VJCC	VJMC	3.78000*	.82936	.000	1.8688
VJCL	VJMC	5.76000*	.82936	.000	3.8488
* The mean difference is significant at the 0.05 level.					

3. Evaluation of Elongation test

In Butt joint groups:
As shown in the table (9) the maximum value of elongation appears in group 5(BJCL) 4.5760 mm where the fracture surface treated with chloroform and lignin, While the minimum value was observed in the control group (BJMC) 2.6040 mm.

Table 9: Mean, Standard Deviation and ANOVA Test Results of Elongation. (mm) for Butt Joint with different surface treatments groups

Groups	*Mean*	*S. D*	*S. E*	*Min.*	*Max.*
BJMC	2.6040	.61958	.27708	1.86	3.34
BJAC	2.6100	.62209	.27821	1.65	3.33
BJAL	2.1340	.48258	.21581	1.34	2.58
BJCC	4.3100	.34936	.15624	3.90	4.81
BJCL	4.5760	.49778	.22261	3.77	5.09
ANOVA	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	24.771	4	6.193	22.542	.000
Within Groups	5.494	45	.275		
Total	30.265	49			

The ANOVA- test for Elongation changes in Butt joint revealed a highly significant difference between the groups as shown in the table (9).

Multiple comparisons between the control group and experimental groups were observed a highly significant difference in group 4 (BJCC) and group 5(BJCL) with the control group, while non-significant differences in the other groups as shown in the table (10).

Table 10: Multiple Comparison ofElongation Test Results(mm) for Butt Joint groups

Dunnett t (>control)					
(I) Sample .BJ	*(J) Sample. BJ*	*Mean Difference (I-J)*	*S. E*	*Sig.*	*95% Confidence Interval*
					Lower Bound
BJAC	BJMC	.00600	.33149	.794	-.7579
BJAL	BJMC	-.47000	.33149	.992	-1.2339
BJCC	BJMC	1.70600*	.33149	.000	.9421
BJCL	BJMC	1.97200*	.33149	.000	1.2081
*. The mean difference is significant at the 0.05 level.					

1. In Bevelled joint group:

As shown in the table (11) the maximum value of elongation appears in group 5(VJCL) 5.2200 mm where the fracture surface treated with chloroform and lignin, While the minimum value was observed in the control group (VJMC) 3.7880 mm.

Table 11: Mean, Standard Deviation and ANOVA Test Results of Elongation (mm) for Bevelled Joint with different surface treatments groups

Elongation.VJ(mm)					
Groups	*Mean*	*S. D*	*S. E*	*Min.*	*Max.*
VJMC	3.7880	.35010	.15657	3.22	4.15
VJAC	4.9740	.45987	.20566	4.48	5.48
VJAL	4.9240	.27979	.12512	4.65	5.24
VJCC	5.0260	.58812	.26301	4.14	5.63
VJCL	5.2200	.16956	.07583	5.05	5.42
ANOVA	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6.482	4	1.620	10.296	.000
Within Groups	3.148	45	.157		
Total	9.630	49			

The ANOVA- test for Elongation changes in Bevelled joint revealed a highly significant difference between the groups as shown in the table (11).

Multiple comparisons between the control group and experimental groups were observed a highly significant difference in all groups as shown in the table (12).

Table 12: Multiple Comparison of Elongation Test Results(mm) for Bevelled Joint groups

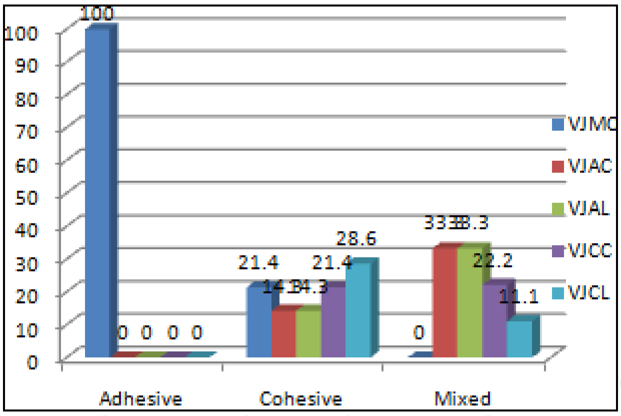
Dunnett t (>control)					
(I) Sample. VJ	(J) Sample VJ	Mean Difference (I-J)	S. E	Sig.	95% Confidence Interval
					Lower Bound
VJAC	VJMC	1.18600*	.25091	.000	.6078
VJAL	VJMC	1.13600*	.25091	.000	.5578
VJCC	VJMC	1.23800*	.25091	.000	.6598
VJCL	VJMC	1.43200*	.25091	.000	.8538
*. The mean difference is significant at the 0.05 level.					

Types of failure:

1. The specimens showed three types of failures including adhesive, cohesive and mixed. Table (13) and figure (1) represents the types of failure in Butt joint group in that the adhesive fracture were the most common type (68.0%) and the maximum value was observed in group 2(BJAC) 29.4%, While the minimum value was observed in group 5(BJCL) 5.9%.

Table 13: Types of failure * Butt joint Groups Crosstabulation

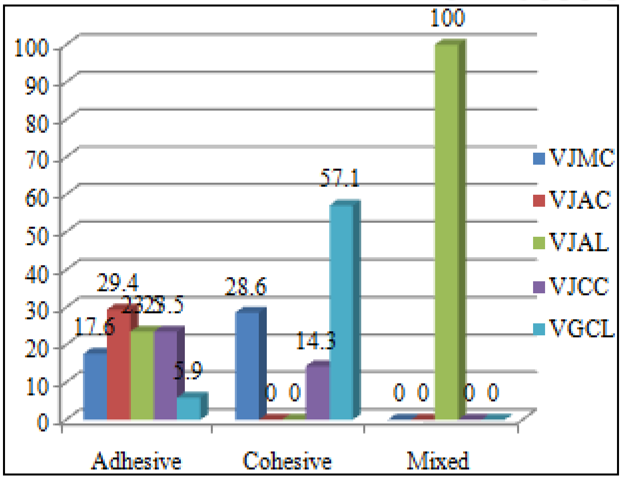
			Butt joint Groups					*Total*
			BJMC	*BJAC*	*BJAL*	*BJCC*	*BJCL*	
Types of failure	Adhesive	Count	6	10	8	8	2	34
		% within Types of failure	17.6%	29.4%	23.5%	23.5%	5.9%	100.0%
		% of Total	12.0%	20.0%	16.0%	16.0%	4.0%	68.0%
	Cohesive	Count	4	0	0	2	8	14
		% within Types of failure	28.6%	.0%	.0%	14.3%	57.1%	100.0%
		% of Total	8.0%	.0%	.0%	4.0%	16.0%	28.0%
	Mixed	Count	0	0	2	0	0	2
		% within Types of failure	.0%	.0%	100.0%	.0%	.0%	100.0%
		% of Total	.0%	.0%	4.0%	.0%	.0%	4.0%



From table (14) and figure (2) which represents the types of failure in Bevelled joint group it was observed that the cohesive fracture was the most common type (56.0%) and the maximum value was observed in group 5(VJCL) 28.6%, While the minimum value was observed in group 2(VJAC) and 3(VJAL) 14.3%.

Table 14: Types of failure for* Bevelled joint Groups Crosstabulation

			Beveled joint Groups					*Total*
			VJMC	*VJAC*	*VJAL*	*VJCC*	*VJCL*	
Types of failure	Adhesive	Count	4	0	0	0	0	4
		% within Types of failure	100.0%	.0%	.0%	.0%	.0%	100.0%
		% of Total	8.0%	.0%	.0%	.0%	.0%	8.0%
	Cohesive	Count	6	4	4	6	8	28
		% within Types of failure	21.4%	14.3%	14.3%	21.4%	28.6%	100.0%
		% of Total	12.0%	8.0%	8.0%	12.0%	16.0%	56.0%
	Mixed	Count	0	6	6	4	2	18
		% within Types of failure	.0%	33.3%	33.3%	22.2%	11.1%	100.0%
		% of Total	.0%	12.0%	12.0%	8.0%	4.0%	36.0%



4. Discussion

The improvement of the chemical, physical, and biocompatible properties of acrylic resin cannot solve the most common problems of denture fracture that encounter by prosthodontics and patient.[3-7,9]. Over the years, different methods were considered to related with broken dentures, like reinforcement of the denture fractured fragments, modifying contours of repaired surface using different denture repair material, and utilizing different processing methods[2,3,9,14,44].

Complete denture Repair can be simple or complex. They may include the replacement of missing tooth or teeth and/ or fractured pieces of a denture base [49].

Repairs with auto polymerized are easy to performed, inexpensive and not required much time. The strength of auto polymerized resin repairs has been appeared to be just 18% to 75% of that of unbroken, heat-cured resin

[2,6,9,15,19,49]. One of the specifications for an effective repair i.e. rebuilding of the denture's native strength, can't generally be accomplished.

In this study, the lower in strength were found to be in the control specimens repaired with a conventional method more than those repaired by modified acrylic with surface treatments. This could be a direct result of increment in the polymerization temperature, causing the acetone and chloroform to perforate and spread further into the resinframework there by expanding the obligation of the two joining surfaces.

The results appeared among the different biomaterials studied have a tendency to affirm previous findings [4,6,9,44,49]. that the selection ofa repair resin is of significant importance for the strength of the bondbetween the resins[4,6,49].

Bond strength can be influenced by many factors including degree of contamination during processing, cross- linking of the materials, thermal stresses and availability accessibility of solvents. [50]. **(Patil et al, 2006).**

This study was carried out to assess the effect of different types of surface treatments under transverse, impact strength test for acrylic specimens constructed from heat cure acrylic materials repaired by cold cure acrylic and cold cure acrylic with lignin.

4.1. Transverse bond strength test

Fracture of acrylic denture base remain to be a problem and numerous effort has been made to enhance the mechanical properties of denture base material [3,6,7]. One approach is to have (PMMA) material reinforced and strengthen by modifying conventional cold cured acrylic resin chemically through the addition of lignin[51]. (**Foat et al.,2009).**

The test was chosen in (1939), because it mimics the flexural stacking that an upper denture gets amid mastication. The assessment of PMMA denture base by transverse bond strength test depends on three- point bending system since it simulates the loading arrangement in the clinical circumstance[5,19,56].
The results of transverse bond strength test for butt joint samples after different surface treatment for conventional and modified acrylic denture base material were listed in the table (1).

In this study, the BJCL denture base acrylic resin showed the highest mean value for transverse bond strength followed by BJCC simplified heat cure denture base and the lowest mean value was for conventional heat cure denture base treated with a monomer.

These findings may be due to the effect of reactive functional group of lignin that reacts with acrylic denture base and the roughness obtained from the surface treatment with chloroform, also the use of heat and pressure (Ivomet) during the curing time, these results was agreed with the findings of [43]Vojdani M. et al 2008 that the transverse bond strength of repaired materials to denture base increased significantly with chemical treatments (monomer, acetone, and chloroform) but there is no significant difference between the three type of chemicals. These chemicals scratch the surface by changes the morphology and substance properties of the materials. Surface treatment cause harshness of the surface like pits, split which improved the bond of the repaired material as stated by Sarac 2005[44]that the methylene chloride produced a smoother surface than aceton and monomer and dissolve the PMMA base and created roughness that increases the adhesion. Also agreed withAlkurt, 2014[5].Polat et al 2013[25], Rached 2001[48],Valittue1994[19]. they reviled that surface treatment withchemicals increased repair strength may be due to infiltration of monomer into the pits and cracks and the increase in the wetting time with monomer for the repaired surface could enhance the flexural strength.Rached and Del Bel Cury[48].improved that treatment of acrylic resin surface with acetone showed a cleaner and smoother surface than the monomer.

The transverse strength of bevelled joint had a higher value than that for a butt joint as shown in table (3), and the highest one is that treated with chloroform and reinforced with lignin, the bevel joint design may be influenced to increase the strength which expands interfacial bond zone and moves the interfacial stress design more towards a shear stress and far from all the more harming tensile stress during repair as stated by Hanna et al. in 2010[50].,and Anasane 2013 when they used auto polymerized resin with glass fibers reinforced with silane coupling agent having butt and bevelling joint design for repairing of heat cure acrylic resin. Also agreed withPereira 2010 [6].Bural et al 2010[5].(and Mahajan 2014[2] who reviled that the modification of the shape of joint surfaces may enhanced the flexural strength and affect the adhesion properties of the repaired resin and the butt joint not give the better strength due to the stress concentration from the sharp angle and the round shape is the best design,treatment withPMMA monomers and acetone increased flexural strength, modulus of elasticity,fracture load of visible light cureresins repaired material. In the present study, the highly significant differences between the group treated with chloroform and lignin with the control group may be due to the increase in the cross- linking of a polymer by the reaction of the functional group of lignin and auto polymerized acrylic resin.

Impact strength

The highest impact strength was shown to be in group 5 (VJCL) (repaired with cold cure and lignin and treated with chloroform having beveling joint 8.2200 KJ/m2 with a highly significant result from ANOVA and Dunnett test. While for the butt joint there is no significant differences and the highest value also in group 5(VJCL) 2.9200 KJ/m2. These results were indicated that the effect of bevelling joint enhanced in increased the impact strength when compared with a butt joint, in addition to the effect of lignin and chloroform. The results of the present study are in agreement with the findings obtained by, (25)Kanie et al (2000) andHanna et al 2010(20), they observed significant increase in impact strength after reinforcement with glass fiber when compared with unreinforced auto polymerized specimens having 45◦ bevel repair surface, also Park et al 2009 (52) and Safarabadi et al 2014(60) found that enhancement of the impact strength of the denture base by rubber graft copolymers as much as 50% and acrylic reinforcement by Al2O and HA have increased the flexural and impact strength

Elongation

Elongation gives information on the capacity of the material to deform prior to failure. Material under tension usually elongate, as stated elongation is (a description of the elasticity of the material), rigid materials usually have lower elongation this is because of the maximum intermolecular powers. The attractive forces between the molecules were increased significantly with the increase in molecular weight which affects the mechanical properties of the materials. (44)(Stevens, 1999).[26]

Hanna 2010, and Polat et al 2013(50) revealed that fiber reinforcement polymers are useful in their application due to the high modulus and strength.

In the present study, elongation value appeared more pronounced in group treated with chloroform and modified with lignin with butt and beveled joint (table..), and a highly significant difference in group 4 and 5(table..) where they treated with chloroform for butt joint while the bevelled joint showed a highly significant difference in all groups(Table…). It is obvious from these results that the presence of chloroform and lignin may enhance the strength and increased the modulus due to the high modulus of elasticity of lignin that can effort more stresses without deformation.

The testing of the samples was done after 2 days of immersion in distilled water at 37 °C, several mechanisms have been suggested to explain the behavior of these materials. The absorbed water usually acts as a plasticizer, allow for slipping of the chains to be pressed on strain and affect elongations, and cause higher tensile strength. This is in agreement with the findings of [57]Gattalemen et al (1977)[52]Al-Khafaje (1998), Stafford and Smith (1968)[53] who reported that probable explanation for the higher tensile strength related to lower water absorption.

Types of failure

During testing of the impact specimens the type of failure was examined visually, the nature of failure noted in this study was mainly adhesive 68% for butt joint group and 8.0% for bevel joint, While cohesive type was 28% and 56% respectively as shown in table (13) , (14) and chart (1), (2).

The samples with butt joint showed high percentage of adhesive failure type of fracture, since these groups showed low bond strength compared with the repaired surface specimens having 45◦ bevel joint and modified with lignin which reviled a very low percentage of this type of failure (8%) indicating the bond failed at the interface of the fractured surface and repaired material due to the effect of morphology of the intact surface and the interaction of lignin with the polymer .These results was in accordance with previous findings of (48,8, 43)(Takahashi et al .,2000; Rached et al.,2004; Abdul-Hadi,2007) Polyzois 2001(10),Polat 2013 [25] Rached 2001[48],Mahajan 2014[2] that the butt joint show more an adhesive type of failure while other designs like round, rabbit, bevelled joint have more cohesive type.

The effect of surface treatment shown that the samples treated with chloroform reviled the lowest percentage of adhesive fracture and more type of cohesive indicating that the surface treatment will enhance in bonding between the repaired joint and the repaired material specially chloroform more than monomer and acetone, these findings was agreed with Shihab 2013, Sulaiman 2012, Agarwal et al,2008, Takahashi et al .,2000; Rached et al.,2004; Abdul-Hadi,2007 Rached 2001[48],. While Vallittue 1994[19] found that the increase in time of monomer wetting had to decrease the No. of adhesive failure.

5. Conclusions

The present study showed that:

1) The transverse strength value of the fractured specimen repaired by cold cure acrylic modified with lignin revealed a high significant difference than the conventional cold cure acrylic
2) Wetting the repaired joint with chloroform have the highest transverse value as compared with that treated with monomer and acetone.
3) The repaired specimens with a bevel joint having a high significant difference than that treated with a butt joint in transverse and impact strength test.
4) The surface treatment and addition of lignin had not significantly affected the impact strength of specimens with a butt joint.
5) The type of failure for specimens having butt joint showed a high percentage of adhesive failure, while that have bevel joint exhibit a high percentage of the cohesive and mixed type of failure.

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