Evaluation Of The Transverse Strength Of Denture Base Resins Repaired With Conventional Heat Cure Or Autopolymerising Resins Under Different Surface Treatments- An In Vitro Study

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Abstracts: Aim: Acrylic resin dentures are susceptible to fracture after clinical use. The denture repair should be easy, strong and should not affect the dimensional accurac. Objective: The study was conducted with an objective of evaluating the transverse strength of two types of heat cure resins when repaired with different types of heat cure and autopolymerizing acrylic resins under different surface treatments. Methods: 195 rectangular specimens (65.0 x 10.0 x 3.3mm) of DPI-Heat Cure and Acralyn H were fabricated according to ADA Specification No.12, and stored in distilled water at room temperature for 7 days. 15 specimens of each material remained intact (control). 180 specimens of each material were sectioned in the middle to create a 10mm gap. 60 specimens each were treated with different surface treatments like wetting with methylmethacrylate monomer for 180sec and air borne particle abrasion for 5sec and 60 specimens were repaired without any surface treatment. Among these 60 specimens, 15 each were repaired with materials DPI-Heat Cure, Acralyn H, DPI-RR and Acralyn R. After an additional 7 days of storage at room temperature, the transverse strength of intact and repaired specimens was measured using a 3 point bending test in Universal Testing Machine. The nature of failure was noted as adhesive, cohesive or mixed. The data obtained was subjected to statistical analysis. The mean and standard deviation were calculated for each group. Result: The intact DPI- heat cure specimens had higher strength than Acralyn H. When repaired with heat cure repair resins the strength was higher compared to autopolymerizing resins. Repaired specimens exhibited 3 types of failure; adhesive, cohesive and mixed, with an incidence of 15.6%, 25% and 59.4% respectively. Adhesive failure was commonly seen with no surface treatment. Cohesive type of failure was increased with chemical and mechanical surface treatments. Conclusion: As heat polymerising resins have better strength and the properties than autopolymerising resins, it should more often be used as repair material. [Sankeshwari B NJIRM 2017; 8(1): 60-65]

Key Words: acrylic resin, chemical surface treatment, flexural strength, heat cure resin, mechanical surface treatment, repair materials, self cure resin, strength, surface treatments, transverse strength.

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Introduction: The loss of teeth is a matter of great concern to the majority of people and their replacement by artificial substitutes such as dentures, is vital to the continuance of normal life. The material most commonly employed in the fabrication of dentures is the acrylic resin poly (methyl methacrylate). Despite its popularity, the material, although adequate in satisfying aesthetic demands, is far from ideal in fulfilling the mechanical requirements of such prostheses. This is reflected in the unresolved problem of denture fracture and the accompanying costs to affect repair.[1]

Denture repairs involve joining two parts of a fractured denture with a denture repair material.[1] Failure of adhesion between repair material and the denture base resin results in a weak bond and can create a potential surface for bacterial growth, promote staining or result in complete delamination of the repair and denture base resin.[2]

Attempts to improve the bond strength by means of chemical or mechanical surface modifications of denture base resins have also been described. Mechanical and chemical modifications like grinding with burs, increasing the surface area by air abrasives or solvents like methylmethacrylate monomer or acetone can be used to improve the bond strength of repair materials to denture base.[3,4]

There are not many studies which have compared the effect of mechanical and chemical surface treatments on the bond strength. Hence the study was undertaken to evaluate the transverse strength of repair material of different brands of auto polymerizing and heat polymerizing resins when subjected to various surface treatments and to determine the nature of failure of repaired specimens as adhesive, cohesive or mixed.

Methods: The study was carried out in Department of Prosthodontics, KLE`S Institute of Dental Sciences,

Bangalore.Metal specimens of dimensions 65mm x 10mm x 3.3mm were prepared by a tool manufacturer.

Type III dental stone was used to invest metal dies (as done in compression molding technique). Before investing, the metal dies were coated with a thin layer of petroleum jelly (Bioline) for easy removal of the die once the dental stone had set. For easy removal of the metal dies, without fracture of the molds, a space was created on one side of the metal dies in the first pour of dental stone (fig 1). The space allowed for easy retrieval of the metal dies once the second pour had set completely. A layer of cold mold seal was applied before trial as well as final closure.

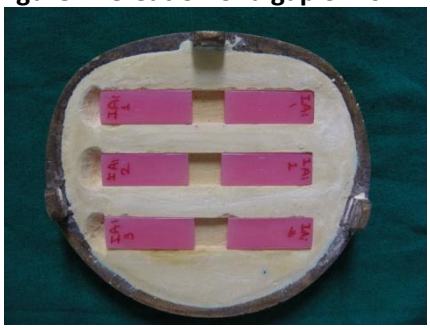
Figure 1: Investing metal dies

The mix of polymethylmethacrylate was prepared according to the manufacturer's instructions in a porcelain mixing jar. Each flask was packed with acrylic resin once it reached dough stage. Excess material (flash) was removed during trial closure. These flasks were kept under 100 psi pressure in a hydraulic press and then clamped. They were then allowed to bench cure for 24 hours. After a 24 hr period of bench curing, the flasks were placed in the acrylizer for processing. The long curing cycle was followed i.e. curing at 74^0C for 8 hr. These flasks were allowed to bench cool before deflasking. Following bench cooling procedure, flasks were opened and acrylic patterns were carefully retrieved. The excess flash was trimmed using a laboratory micromotor (AC motor) and polished.

Group I – 195 samples of DPI heat cure material
Group II – 195 samples of Acralyn H heat cure material
After storage of the samples in distilled water for 7 days at room temperature, the samples were fractured at the midline using a double sided carborundum trimming disk. A gap of 10mm was created between the fractured specimens, by removing the acrylic resin.

Preparation of the fractured surfaces: - The fractured surfaces were cleaned with distilled water and dried with a blast of air. The surfaces were then treated with either of two surface treatments and were classified into 3 groups of 60 specimens each.
No treatment Wetting with methylmethacrylate monomer for 180sec
Aluminium oxide air abrasion for 5sec
The fractured specimens were placed in the prepared molds in such a way that 10 mm gap existed between the 2 sections of the specimens (fig 2). Each of these main groups was further classified into 4 subgroups of 15 specimens each based on the repair material used.
i. Heat polymerizing resin- DPI
ii. Heat polymerizing resin- Acralyn H
iii. Autopolymerizing resin- DPI- RR
iv. Autopolymerizing resin – Acralyn R

Figure 2: Creation of a gap of 10mm



The heat cure material was processed as previously described according to the manufacturer's directions. The autopolymerizing resins were processed in pressure pot under warm water for 20min at 20 psi.

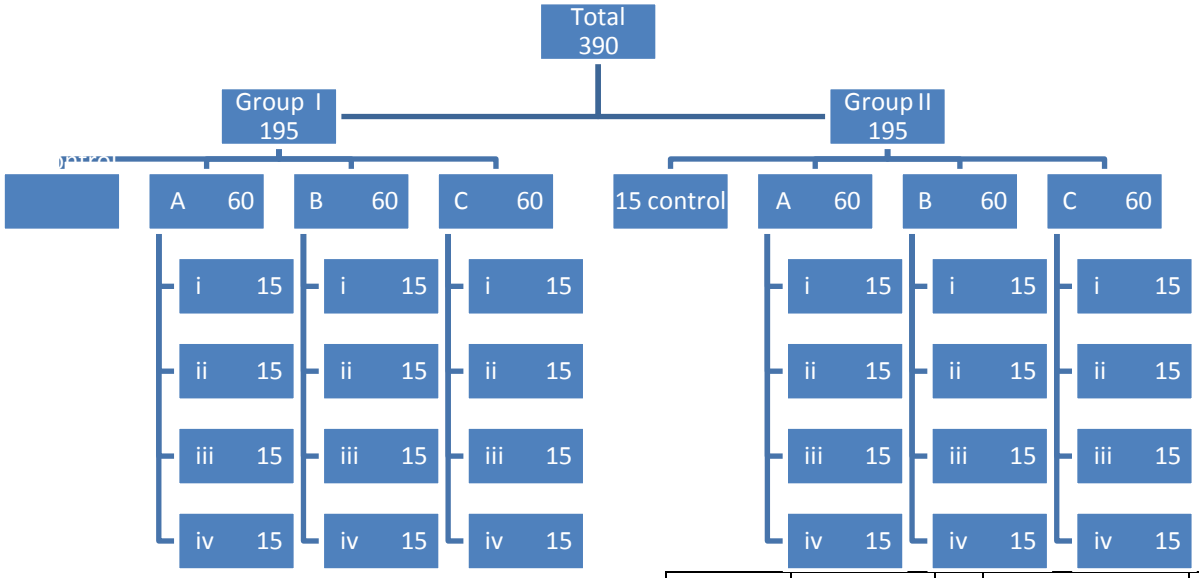
Figure 3: Measurement of Transverse Strength

The transverse strength of the repaired and the intact specimens were measured using a 3 point bending test in a Universal testing machine with a 10000 kg load cell at a cross head speed of 5mm/min (fig 3).

The transverse strength(s) of each specimen was determined using the formula

$$S = \frac{3WL}{2bd^2}$$

where W - the fracture load, L - The distance between the supports (50.0 mm)
b - The specimen width
d - The specimen thickness
The nature of fracture was noted as adhesive, cohesive or mixed by visual inspection of the fractured specimens. If the fracture occurred at the interface of the repair material and the main material –adhesive fracture entirely in the repair material or main material-cohesive fracture traversed both at the interface and at the repair material - mixed fracture



Result: The data obtained was subjected to statistical analysis. The mean and standard deviation was calculated for each group. The proportions were compared using Chi square test and One way analyses of variance (ANOVA) was used to test the difference between groups. In all the above test P value less than 0.05 were taken to be statistically significant. The data was analyzed using SPSS package. On comparison of transverse strength of intact specimens of both the groups, the DPI specimens had higher strength (10.515) than Acralyn H (8.824) which was statistically significant (table 1).

Table 1: Transverse strength (MPa) of intact specimens

Group	Mean strength	SD
Group 1	10.515	1.0556
Group 2	8.824	2.8683

On comparison of transverse strength of Group 1specimens when repaired, there was significant difference present between the surface treatments carried out and the repair materials used (table 2).

Group	Subgroup		Mean strength	SD
Group 1	A	i	9.033	2.5322
		ii	8.880	2.7604
		iii	3.877	1.5705
		iv	4.458	1.3694
	B	i	8.124	2.8881
		ii	7.246	1.9639
		iii	5.680	1.7094
		iv	6.103	0.4616
	C	i	9.926	2.5996
		ii	6.252	1.8633
		iii	4.617	2.0269
		iv	5.475	1.7292

Table 3: Comparison between repair materials under different surface treatments

Group	Subgroup	Comparison		'p' value	Inference
Group 1	A	i	ii	1.000	Not significant
		i	iii	<0.001	Significant
		i	iv	<0.001	Significant
		ii	iii	<0.001	Significant
		ii	iv	<0.001	Significant
		iii	iv	0.976	Not significant
	B	i	ii	0.783	Not significant
		i	iii	0.007	Significant
		i	iv	0.038	Significant
		ii	iii	0.181	Not significant
		ii	iv	0.521	Not significant
		iii	iv	0.992	Not significant

	C	i	ii	<0.001	Significant
		i	iii	<0.001	Significant
		I	iv	<0.001	Significant
		Ii	iii	0.197	Not significant
		Ii	iv	0.893	Not significant
		iii	iv	0.841	Not significant

Transverse strength of Group 2 specimens when compared showed statistical difference when repaired with different repair materials with no or chemical surface treatment (table 4)

Table 4: Transverse strength (MPa) of repaired specimens of group II under different surface treatments and repair materials

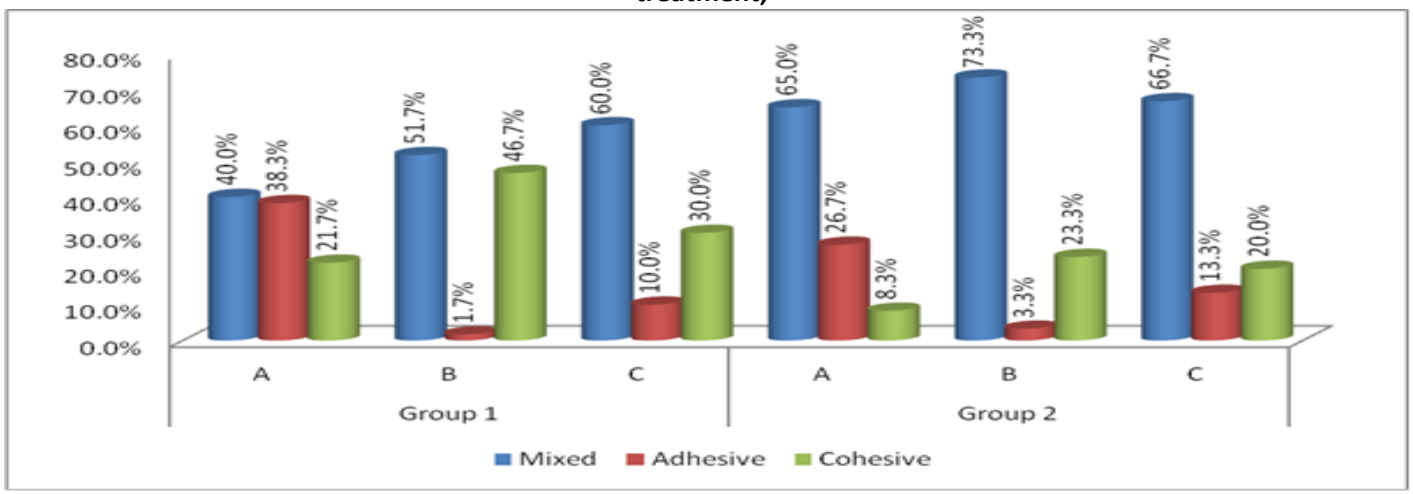
Group	Subgroup		Mean strength	SD
Group 2	A	i	9.772	4.2316
		ii	10.018	3.0577
		iii	5.225	2.9909
		iv	8.090	1.9400
	B	i	8.614	2.8347
		ii	10.064	3.1325
		iii	5.829	2.1748
		iv	7.834	2.4500
	C	i	7.738	3.0128
		ii	7.610	2.6213
		iii	6.887	1.7657
		iv	6.893	2.6048

Table 5 shows that on comparison of transverse strength between the repair materials used for group 2, the results were statistically significant for
Subgroup A: i & iii, ii & iii
Subgroup B: i & iii, ii & iii
Subgroup C: not significant

Table 5: Comparison between repair materials under different surface treatments for group II

Group	Sub group	Comparison		'p' value	Inference
Group 2	A	I	ii	1.000	Not significant
		I	iii	0.001	Significant
		I	iv	0.625	Not significant
		ii	iii	0.001	Significant
		ii	iv	0.470	Not significant
		iii	iv	0.093	Not significant
	B	I	ii	0.604	Not significant
		I	iii	0.036	Significant
		I	iv	0.965	Not significant
		ii	iii	0.000	Significant
		ii	iv	0.147	Not significant
		iii	iv	0.240	Not significant
	C	i	ii	1.000	Not significant
		i	iii	0.933	Not significant
		i	iv	0.936	Not significant
		ii	iii	0.969	Not significant
		ii	iv	0.970	Not significant
		iii	iv	1.000	Not significant

Graph 1: represents type of failure when compared showed significant difference with the type of surface treatment,



For group 1, Adhesive type of failure is least with chemical surface treatment (1.7%) followed by mechanical (10%) and no surface treatment (38.3%). Cohesive type of failure was highest with chemical surface treatment (46.7%) followed by mechanical (30%) and no surface treatments (21.7%). Mixed type of failure was highest with mechanical (60%) followed by chemical (51.7%) and no surface treatments (40%). For group 2, Adhesive type of failure is least with chemical surface treatment (3.3%) followed by

mechanical (13.3%) and no surface treatment (26.7%).

Cohesive type of failure was highest with chemical surface treatment (23.3%) followed by mechanical (20%) and no surface treatments (8.3%).

Mixed type of failure was highest with chemical (73.3%) followed by mechanical (66.7%) and no surface treatments (65%).

Discussion: Acrylic resin polymers were introduced as a denture base material in 1937; and by 1946, 98% of all denture bases were fabricated from polymethyl methacrylate (PMMA) or copolymers. Today, the majority of dentures are made from heat-cured PMMA.[5] Results of a survey showed that 33% of the repairs carried out were due to debonded or detached teeth and 29% were repairs to midline fractures.[6] The fracture of maxillary to mandibular dentures is at a ratio of 2: 1.[7]

Denture fracture can occur both outside and inside the mouth. Outside the mouth, failure can occur through impact as a result of dropping of the dentures. The various causes of denture fracture inside the mouth are: excessive bite force, improper occlusal plane, high frenal attachment, limitations of denture base material etc.[8,9] In function however, midline fracture is the result of flexural fatigue failure caused by cyclic deformation of the base and is more likely to occur because flexure of the denture base occurs along the midline.

Denture fractures are usually repaired to minimize inconvenience to the patient and to save the cost in reconstruction of dentures and the success depends on the strong repair junction. Hence, this study was undertaken to evaluate the transverse strengths of two types of denture base resins when repaired with different types of commercially available heat cure and autopolymerising resins. The popular brands available in market like DPI (heat and autopolymerising resin) and Acralyn (heat and autopolymerising resin) were chosen for the study.

Basic research on the nature of adhesion has shown that the fracture should not occur along the interface as it is strongest part of the joint.[10] Shen et al reported that the fractures of the repaired specimens often occur at the junction of the old and new material, where the greatest force is applied.[8] Hence, it was necessary to study the type of fracture as adhesive, cohesive or mixed.

When compared to the strength with control specimens, the DPI repaired specimens had lower strength. The control specimens of DPI showed an average strength of 10.515 MPa whereas, after repair it showed an average of 8.243 MPa when repaired with same heat cure material. The strength of Acralyn H before and after repair with same heat cure repair material was not significantly significant.

The results of this study showed that when the repair materials were compared, heat cure resins have better bond strength than autopolymerising resins. The strength when repaired with heat cure resins was found to be about 89% compared to control whereas, with self cure it was found to be about 61.16%. This result is in agreement with the studies conducted by Rosangela et al, John et al which found that when repaired with autopolymerising resin the specimens have approximately 60% to 65% of the original strength while with the heat polymerising resin have 75% to 80% of the original strength.[8,11]

It was interesting to note that, DPI specimens when repaired with the same material i.e. DPI heat cure, had higher strength than other three repair materials and Acralyn H when repaired with same heat cure Acralyn H had higher strength. For Acralyn H, between the self cure repair resins when it was compared, the same brand i.e. Acralyn R had higher strength than when repaired with DPI self cure.

The type of failure was influenced by the surface treatment received. With chemical and mechanical treatments the number of adhesive failures was significantly reduced and cohesive failures were significantly increased for groups 1 and 2, thus showing that the bond between the denture base and repair material was not a compromise. These results are similar with the studies by Eiichi et al, Minami et al which found that the bonding is increased for chemical surface treatment because the monomers from the repair material may form a penetrating network across the interface onto the parts to be joined.[3, 12] For mechanical surface treatment the bond is increased due to increase in surface area.

Finally it must be noted that in- vitro studies are limited in predicting the success of a material or technique in clinical use.

Conclusion: The present study showed that there are significant differences on the strength of repaired specimens as influenced by repair material. As heat polymerising resins have better strength and the properties than autopolymerising resins, it should more often be used as repair material.

Prior to repairing the dentures proper mechanical or chemical surface treatment of the fractured parts should be carried out in order to achieve stronger bond. As the type of failure noticed in the study was of a mixed or cohesive type, it implies that the adhesion between the materials is also equally important to the strength of the repair material.

Limitations Of The Study:

1. Rectangular shaped specimens were used for the study which does not simulate the a anatomy of the denture base.
2. The factors like, distortion following double heat processing for heat cure repair material, color stability were not considered.
3. Repair surface with only butt joint and a gap of 10mm was checked.

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