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ORIGINAL RESEARCH

Comparative Evaluation of Shear Compressive Bond Strength between Cross-linked Acrylic Resin Denture Base and Cross-linked Acrylic Resin Teeth with Different Modifications of Their Ridge Lap Surfaces

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ABSTRACT

A major problem commonly observed in denture wearer is the detachment of artificial tooth/teeth from acrylic denture base. The problem was grave when porcelain teeth used along with the then available denture base materials. The bond formed was purely mechanical and hence debonding of teeth from denture base was a frequent occurrence.

Inspite of chemical union between acrylic resin teeth and acrylic denture base material, detachment of teeth particularly anterior teeth is a frequent observation.

The objective of the study is to study the effect of change in the surface treatment and surface configuration of ridge lap surface of the teeth on retention of cross-linked acrylic teeth on cross-linked acrylic resin denture base. Sixty specimens were tested for the shear compressive bond strength using instron universal testing machine in KN. Statistical analysis is used. The findings were analyzed using one-way analysis of variance (ANOVA) and 't' test. Slight modification in the ridge lap surface of artificial teeth alters the strength of the shear compressive bond. Sand papering of ridge lap surfaces improves the shear compressive bond then the one without any modification. Maximum shear compressive bond strength can be increased by application of monomer.

Keywords: Cross-linked acrylic resin teeth, Cross-linked acrylic resin denture - base, Shear compressive bond strength, Ridge lap.

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INTRODUCTION

Detachment of the artificial teeth from denture base still remains a major problem in prosthodontics practice. Acrylic resin teeth have advantage over porcelain teeth which were used routinely in the past. Acrylic resin teeth unite chemically to the denture base resin. Bonding failures of acrylic resin teeth to the acrylic denture base are mainly attributed to.[1,2]

The composition of the material for example the extent of cross-linking depends upon the percentage of cross-linking agent present in the resin.

Indiscriminate use of separating medium per mix pooling of the separating medium at the neck of the teeth there by interfering in the chemical bonding of artificial teeth to the denture base resin.

Faulty and/or incomplete boil out procedure fails to eliminate traces of wax from the ridge lap surface of the teeth.

Following procedures can be attempted to increase the bond strength between acrylic resin teeth and heat cure acrylic resin denture base.

They are, resurfacing grinding the glossy ridge lap surface of the teeth.

Application of monomer solution on the ridge lap surface of the teeth.

Formation of different types of grooves on the ridge lap surface.

This study is an attempt to determine whether slight resurfacing of the ridge lap surface of artificial teeth or application of methylmethacrylate monomer to the ridge lap surface of the teeth just prior to packing of the denture base

resin in the mold or preparing horizontal or vertical grooves or both the horizontal and vertical grooves in the ridge lap surface of acrylic resin teeth would improve the combined shear compressive strength of the bond between the artificial cross-linked acrylic resin teeth and the cross-linked acrylic resin denture base, which are more commonly used today as cross-linked resin have higher rigidity, decreased water sorption than conventional acrylic resin teeth and denture base material.

MATERIALS AND METHODS

The material used in the study is as follows:

1. Sixty cross-linked acrylic resin central incisors of the same mold and make (Premadent).
2. Modeling wax for making triangular wax blocks.
3. Dental plaster.
4. Separating medium containing sodium alginate solution — (DPI).
5. Vaseline.
6. Cross-linked heat cure monomethylmethacrylate and polymethylmethacrylate – (DPI).
7. 4% sodium citrate solution.

Method

The shear compressive bond strength was tested using

1. Instron universal testing machine.
2. Stainless steel pin (1 mm diameter).

Preparation of ridge lap surface of sixty central incisors was done in the following manner (Fig. 1).

Group 1: Ten teeth were, kept as they were, i.e. no modification was done to the ridge lap surface (Control group).

Group 2: Glazed surface of ten teeth was removed with coarse sand paper by slightly rubbing it over the ridge lap surface of the teeth for 5 seconds.

Group 3: Ten teeth were kept as they were and the monomer application was done just before packing resin in the mold.

Group 4: Horizontal groove was made in the ridge lap surface of each of the ten central incisors with steel fissure bur no. 2.

Group 5: Vertical groove was made in the ridge lap surface of each of the ten central incisors with steel fissure bur no. 2.

Group 6: Horizontal and vertical grooves were made in the ridge lap surface of the ten central incisors with fissure bur no 2. To prevent slipping of the testing apparatus, a hole 1 mm in diameter was drilled in to the lingual surface of each tooth between tooth and acrylic interface.

Arrangement of Teeth on Triangular Wax Blocks

On each side of the triangular wax blocks central incisors were arranged with the angulation of 130° (Fig. 2). This angulation was chosen to simulate the average angle of contact found between maxillary and mandibular teeth when dentures are in function. Two central incisors were arranged on either side of the triangular wax blocks with inclination of 130° which was confirmed by placing the wax block against the paper on which 130° were marked with lines.

1. Ridge lap surface of two central incisors were left intact, i.e. they were not modified.
2. Two central incisors with glazed surface were roughened with coarse sandpaper for 5 seconds.
3. Two central incisors were kept with no modification of ridge lap surface for monomer application just prior to packing of the resin in the dewaxed mold.
4. Two central incisors with horizontal grooves in the ridge lap surface.
5. Two central incisors with vertical grooves made in the ridge lap surface.

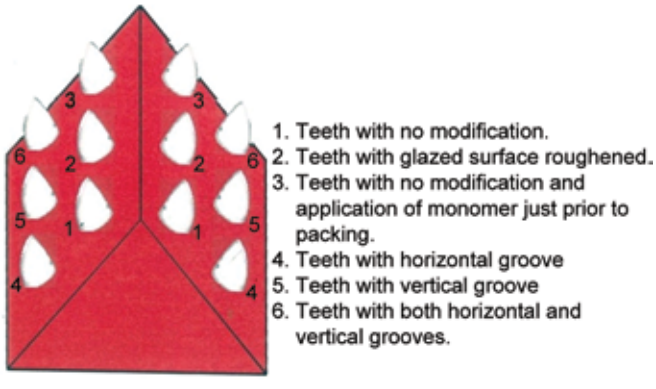


Fig. 1: Schematic representation of arranged central incisors with modification of ridge lap surface on triangular wax blocks

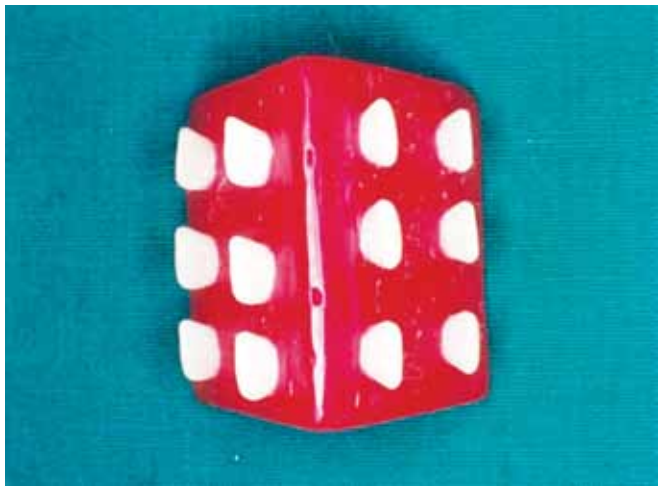
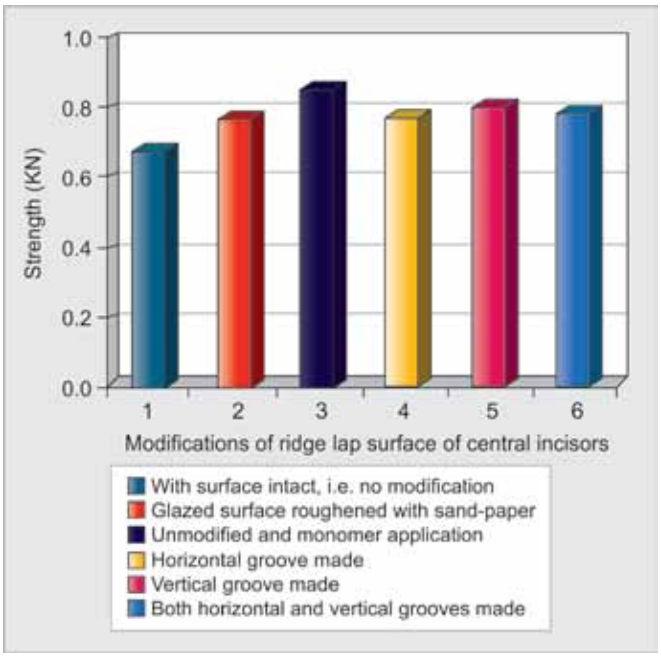


Fig. 2: Arranged central incisors on triangular wax blocks



Graph 1: Shear compressive bond strength of the samples in KN

6. Two central incisors with both horizontal and vertical grooves made in the ridge lap surface.

Thus, in this way twelve teeth were arranged on each block in two rows. Sixty central incisors were arranged on five blocks and wax blocks with mounted incisors were acrylized (Figs 3 and 4).

Measurement of Shear Compressive Bond Strength

After 72 hours, acrylic triangular blocks with arranged teeth were subjected to Instron universal testing machine. Force was applied by a 1 mm diameter stainless steel pin at a crosshead speed of 5 mm/min until the detachment of teeth occurred (Figs 5 to 7).

RESULTS

The statistical analysis of the results showed the following (Tables 1 to 4) (Graph 1):

Slight modification in the ridge lap surface of artificial (Graph 2) teeth alters the strength of the shear compressive

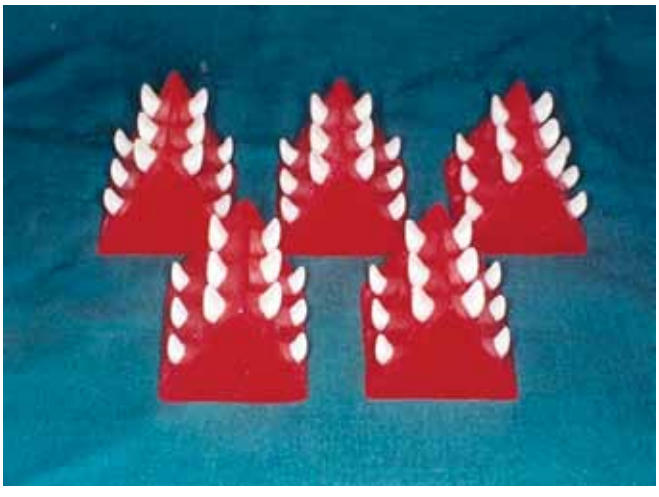


Fig. 3: Sixty central incisors arranged in five wax blocks

Fig. 5: Finished acrylized block ready for the text

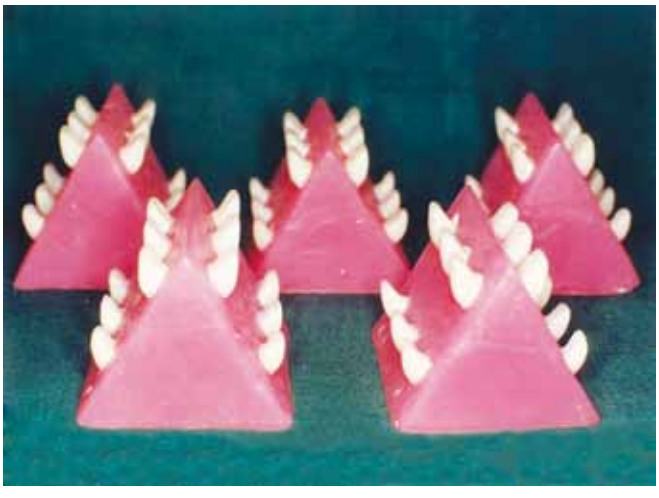


Fig. 4: Five acrylized blocks with sixty central incisors

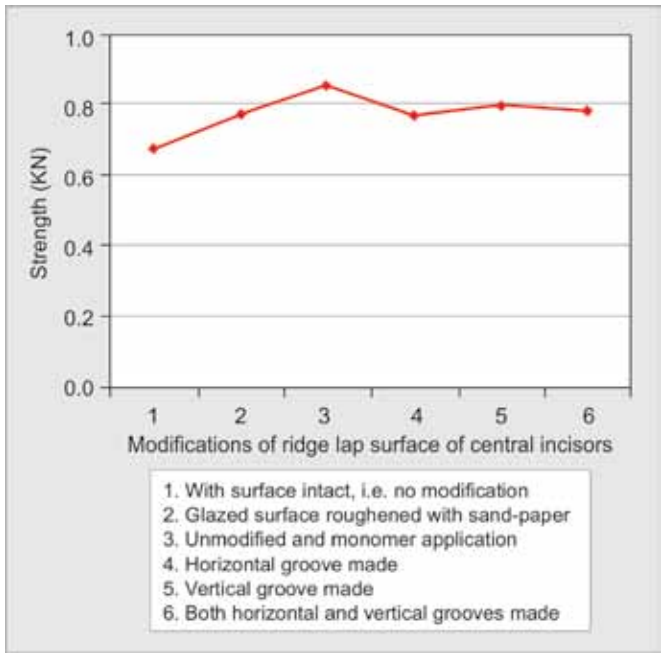
Fig. 6: Angulation between acrylized teeth and the pin

Fig. 7: Acrylized teeth with block fixed with grips for testing

bond between artificial teeth and acrylic denture base resin than the one left intact.

Sand papering of ridge lap surface of artificial teeth improves the shear compressive bond than the one without any modification.

Maximum shear compressive bond strength can be increased by application of monomer of methylmethacrylate.



Graph 2: Shear compressive bond strength of the samples in KN

Statistical analysis was carried out by applying ANOVA test, i.e. Analysis of variance as the F-value is significant at 0.05 and 0.01 level of significance. This is listed in Table 3.

Table 1: Shear comprehensive bond strength of samples tested in KN

Blocks	*Modification of ridge lap surface of central incisors*					
I	0.68	0.77	0.86	0.93	0.79	0.97
	0.61	0.72	0.81	0.76	0.68	0.77
II	0.65	0.80	0.88	0.70	0.89	0.94
	0.60	0.65	0.83	0.74	0.71	0.69
III	0.74	0.88	0.84	0.91	0.83	0.74
	0.65	0.75	0.82	0.73	0.79	0.79
IV	0.84	0.87	0.95	0.76	0.91	0.70
	0.57	0.82	0.89	0.75	0.84	0.74
V	0.84	0.74	0.81	0.67	0.78	0.72
	0.61	0.74	0.84	0.73	0.75	0.74
Samples (N)	10	10	10	10	10	10

STATISTICAL ANALYSIS

The data was analyzed with one-way analysis of variance (ANOVA).The calculated F-value was compared with the table F-value under the specified degree of freedom. Since, the calculated value F is greater than the table value Analysis using one tailed of student 't' test done. Calculated F = 5.2573 which is greater than table value.

F at 0.05 = 2.388

F at 0.01 = 3.382

Hence, F is significant at 0.05 and 0.01 level of significance. So another statistical analysis using of student 't' test done.

Table 2: The mean shear compressive bond strength of the samples in KN per group is listed

Blocks	*Modification of ridge lap surface of central incisors*					
I	0.68	0.77	0.86	0.93	0.79	0.97
	0.61	0.72	0.81	0.76	0.68	0.77
II	0.65	0.80	0.88	0.70	0.89	0.94
	0.60	0.65	0.83	0.74	0.71	0.69
III	0.74	0.88	0.84	0.91	0.83	0.74
	0.65	0.75	0.82	0.73	0.79	0.79
IV	0.84	0.87	0.95	0.76	0.91	0.70
	0.57	0.82	0.89	0.75	0.84	0.74
V	0.84	0.74	0.81	0.67	0.78	0.72
	0.61	0.74	0.84	0.73	0.75	0.74
Samples (N)	10	10	10	10	10	10
Mean	0.678	0.774	0.853	0.768	0.797	0.780
Sum	6.78	7.74	8.53	7.68	7.97	7.80
Std. deviation	0.09249	0.06666	0.04148	0.08047	0.06943	0.09208

Table 3: Analysis of variance

Source of variation	*DF*	*Sum of squares*	*Mean sum of squares*	*Standard deviation*
Among means of modifications of ridge lap surface of central incisors	5	0.1655	0.0331	
Within treatments	54	0.34	0.006296	0.0793
Total	59	0.5055		

Of student 't' test indicated significant differences in mean force between the groups 1 and 3 at $p < 0.05$ level. However, approximately seven differences at 0.05 levels are significant and five differences are significant at 0.01 level.

Table 4: Test of differences by use of student 't' test

Approximately 7 differences significant at 0.05 level ($D_{0.05} = 0.075$)		*Approximately differences significant at 0.01 level ($D_{0.01} = 0.8961$)*	
	Treatments		*Treatments*
0.096	(1 *vs* 2)	0.096	(1 *vs* 2)
0.175	(1 *vs* 3)	0.175	(1 *vs* 3)
0.090	(1 *vs* 4)	0.090	(1 *vs* 4)
0.119	(1 *vs* 5)	0.119	(1 *vs* 5)
0.102	(1 *vs* 6)	0.102	(1 *vs* 6)
0.079	(2 *vs* 3)		
0.085	(3 *vs* 4)		

DISCUSSION

It was observed by Donna Barpal and Donald Curtis et al that most of the dentures that are received for repair require replacement for detached teeth more than the repair of an actual fracture of a denture base. The cause of detachment of teeth are various.[3]

1. Composition of the material for example the extent of copolymerization of the acrylic resin denture base.
2. Poor laboratory technique, including faulty boil out procedure.
3. Indiscriminate use of separating medium and
4. Excessive stress failure, i.e. by fatigue.

It is observed from the review of literature that very few investigators have studied the factors affecting bond strength of the tooth denture base bond. They have tried to improve the bond strength by various methods for example altering the chemical properties of acrylic resin material, application of a monomer solution on the ridge lap surface of the teeth. Some of them have tested the bond strength after modifying the ridge lap surface of teeth by making grooves of different shapes.

Morrrow RM, Matvias F metal have tested the strength of the bond between the acrylic resin tooth and the denture base by applying a tensile force till separation occurred. A major problem with the tensile strength testing was in the preparation and gripping of the sample. The applied force concentrated at surface imperfections and alteration of the ridge lap surface of the teeth.[4]

When maxillary and mandibular anterior teeth come in edge to edge contact, as in incising of food, forces act at an angle of 130° to the long axis of the maxillary central incisors. In this study therefore samples of teeth whose ridge lap surfaces are modified were arranged in a triangular wax block at an angle of 130° so that the Instron testing machine could be used after acrylization of wax blocks with teeth to find the shear compressive strength of the bond between acrylic resin teeth and cross-linked acrylic resin block.

Phillips RW has studied that the cross-linking varies at different levels in artificial teeth. At gingival ridge lap regions cross-linking is of too much lesser degree than at the incisal edge and middle third of the tooth. Chemical union between teeth and denture base resins presumably takes place between outer layers of the tooth and the monomer present in the denture base resin dough.[5]

The Dough containing free monomer must remain in contact with the tooth for a period of sufficient long time to allow the monomer to penetrate the surface layer of ridge lap surfaces of the teeth. On curing, this portion of monomer polymerises across the junction and gives chemical union.[6]

The force required to separate/de-bond acrylic resin teeth which were kept unmodified was the least averaging to 0.678 KN.

Horizontal and vertical groove preparation exhibited still greater force for debonding as still larger surface area of the ridge lap surface of the teeth is exposed to the free monomer of denture base resin during packing by compression molding technique. The average force required to detach central incisors of this group was 0.780 KN.

Roughening of the glazed ridge lap surface by sandpapering for 5 seconds certainly produces numerous very fine capillaries which once again permit mechanical locking along with the chemical union. The average force required to detach central incisors of this group was 0.774 KN.

In the samples exposed to Instron machine with vertical groove preparation exhibited the maximum force required to detach modified artificial teeth from denture base.[7] As the detaching force is acting parallel to the vertical groove the lever arm required to detach teeth from the denture base resin is short, thus maximum resistance is offered by the teeth denture base interface to compressive loading. The average force required to detach the central incisors of this group was 0.797 KN.

Application of monomer methylmethacrylate to the ridge lap surface of central incisors just prior to packing

of acrylic resin dough in the mold literally dissolves and softens the glazed surfaces of unmodified teeth as monomer is an excellent organic solvent.[8-10] Numerous capillaries and cracks thus, produced on the ridge lap surfaces of the teeth due to crazing permit the acrylic resin dough to penetrate into the soft porous surface thus created and polymerized there after curing of the resin block. The average force required to detach the central incisors of this group was 0.853 KN.

Thus, the least time consuming procedure of improving the shear compressive bond strength between artificial teeth and the denture base by applying monomer to ridge lap surfaces of the teeth just prior to packing of acrylic resin in the mold is advocated in routine practice.

The cross-linked acrylic resin teeth with different modification of ridge lap surface will surely exhibit greater shear compressive bond strength between cross-linked acrylic resin teeth and cross-linked acrylic resin denture base, resulting in reduction in detachment of teeth from the denture bases.

CONCLUSION

From the present study following conclusion can be drawn.

Slight modification in the ridge lap surface of artificial teeth alters the strength of the shear compressive bond between artificial teeth and acrylic denture base resin than the ones left intact.

Sandpapering of ridge lap surfaces of artificial teeth improve the shear compressive bond than the one without any modification of the ridge lap surface of the teeth by permitting the acrylic denture base resin to flow into the minute irregularities thus formed.

Maximum shear compressive bond strength can be increased by application of monomer of methylmethacrylate an organic solvent which etches and softens the surface of the ridge lap portion of the teeth thus, improving the mechanical and chemical union between cross-linked acrylic resin teeth and cross-linked acrylic resin denture base.

CLINICAL SIGNIFICANCE

The cross-linked acrylic resin teeth with different modifications of ridge lap surfaces will surely exhibit greater shear compressive bond strength between cross-linked acrylic resin teeth and cross-linked acrylic resin denture base, resulting in reduction in detachment of teeth from the denture bases.

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