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COMPARATIVE EVALUATION OF BOND STRENGTH OF THREE LUTING CEMENTS TO PMMA RESIN - AN INVITRO STUDY

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Abstract

Statement of the problem: The bond strength of PMMA to adhesive and non adhesive cements vary and there is limited evidence on the bond strength of cements to PMMA temporary crown and bridges.

Purpose: The purpose of this invitro study was to evaluate the bond strength of PMMA crowns to three temporary luting cements.

Materials and Methods: A total of 30 recently extracted caries free mandibular second premolars were selected and divided into three groups according to luting cements used[Group 1: Zinc Polycarboxylate cement (Polycem, Medicept); Group 2 : Zinc Oxide Eugenol free luting cement (Template, Prime); Group 3 :Zinc Phosphate cement (Adhesor, Spofa Dental)]. The tooth were mounted on the clear acrylic rectangular blocks of size 8 mm x 8 mm x 20 mm dimensions according to ISO 16506:201. Tooth preparations done and provisional crowns were fabricated using heat cure acrylic PMMA (DPI heat cure tooth moulding powder). Then, these crowns were luted with three temporary luting cements and the bond strength were analysed using universal testing machine (INSTRON 3345). Statistical analysis were done using SPSS 26.0 and compared using one way ANOVA and Tukeys post Hoc test.

Results: The bond strength values of provisional PMMA crown to three different temporary luting cements were 6.37 MPa, 3.39 MPa and 4.40 MPa (Zinc Polycarboxylate cement, Zinc Oxide Eugenol free luting cement, Zinc Phosphate cement). One way ANOVA shows significant difference in the values among the groups ($p<0.05$) which shows that zinc polycarboxylate provides better bond strength compared with that of the zinc phosphate and zinc oxide eugenol free luting cement to PMMA temporary crowns. Tukeys Post Hoc test for comparison between these groups shows no significant difference in their values (p .00) which shows high significant between the groups ($p<0.05$).

Conclusion: Within the limitations of this study, Zinc Polycarboxylate provides better bond strength followed by Zinc Phosphate and Non eugenol luting cement to PMMA temporary crowns.

Clinical Implication: Zinc polycarboxylate is the material of choice for luting long term provisional PMMA crown

Keywords: Zinc poly carboxylate, Zinc oxide eugenol free, Zinc phosphate, PMMA, Provisional restoration, Provisional luting cements

Introduction:

The key to the success of a provisional restorative material depends on its ability to fulfill biological, mechanical, and esthetic requirements until the permanent restoration is luted[1,2]. PMMA is long recognized as a reliable provisional restorative material for FPD[3,4]. Use of long term provisional acrylic FPDs are indicated in selected situations, ranging from weeks to months as per the case demands. Provisional restoration should serve as a template for the final restorations and should provide preview of the future prosthesis by enhancing health of abutment and also periodontium.[5]

Choosing an appropriate temporary cement also depends on the following factors: how long the temporary is needed, which type of tooth to which the provisional is being cemented. The temporary cement chosen must be easily removed and must leave the tooth surface completely cleaned for proper functioning of permanent restoration once placed. Even microscopic remnants of temporary cements interfere with bond of permanent restoration.

Temporary cements with higher compressive strength will withstand occlusal pressures, but will make the temporary restoration harder to remove. Here the bond strength of the luting agent becomes more pertinent than in short term situations.

Zinc phosphate, polycarboxylate and zinc oxide eugenol free were used in this study, because these are the commonly used provisional luting cements for cementation of provisional crowns in routine clinical practice.

The bonding nature of PMMA to adhesive and non adhesive cements can vary 5 and there is limited evidence on the bond strength of cements to PMMA temporary crown and bridges. Hence, the study aims to evaluate the bond strength of PMMA to three temporary luting cements. The null hypothesis is that there is no difference between bond strength of three temporary luting cements to PMMA resin.

Materials and methods:

A total of 30 recently extracted caries free mandibular second premolars of approximately same dimensions were selected. They were cleansed by placing teeth in 1% hydrogen peroxide solution for 24 hours. They were collected from department of oral surgery. Then the roots of teeth were incorporated in clear acrylic resin blocks measuring 8 mm x 8 mm x 20 mm dimensions according to ISO 16506:201(rectangular block). The teeth were embedded in the acrylic block at a level of 2 mm below the cemento-enamel junction.

After this, the mounted teeth were prepared following the principles of tooth preparation, with dental rotary instrument hand piece with diamond bur (TR 12 ISO 199/016). All the dimensions were predetermined to achieve the standardization of the preparation. Flat occlusal reduction, 6° convergences axially, chamfer finish line, height of the crown 5 mm, buccolingual width 5 mm, and mesiodistal width 4 mm6. These were analyzed with digital parallelometer.

After tooth preparation, the aluminium foil was used as a die spacer to obtain the film thickness of the luting cement (25 μm). Then the wax patterns were prepared over the aluminium foil of dimension

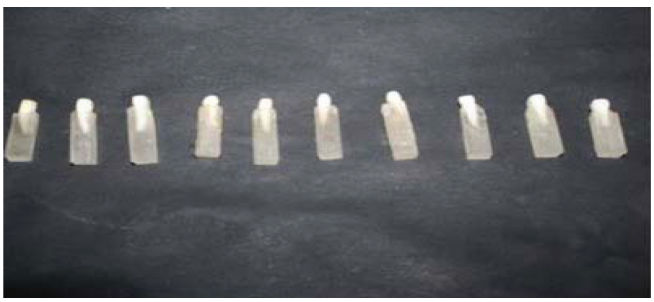

Figure 1: specimens with clear acrylic resin as a base

8 mm x 8 mm x 20 mm (rectangular block). The patterns were then invested using a dental plaster within the flask, dewaxed and packed with heat cure PMMA (DPI heat cure tooth moulding powder) and the provisional crowns were fabricated.

The provisional crowns were divided into three groups based on temporary luting cements as follows:

Group 1: PMMA resin crowns luted with zinc polycarboxylate cement (Polycem, Medicept)

Group 2: PMMA resin crowns luted with zinc oxide eugenol free luting cement (Templute, Prime)

Group 3: PMMA resin crowns luted with zinc phosphate cement(Adhesor, Spofa dental).

Each group had 10 cemented provisional crowns, therefore, making 30 cemented provisional crowns. The cementation was done by single operator using finger pressure. After cementation, it was allowed to set for 24 hours at room temperature for complete setting.

The tensile bond strength of three respective groups were tested using universal testing machine with cross head speed of 1 mm/min until debonding within 500 N force (INSTRON 3345)[6] and the datas were collected.

The datas obtained were subjected to statistical analysis using SPSS 26.0 and analyzed using one way ANOVA for comparison of bond strength with three different temporary luting cements and

Figure 2: Provisional crowns luted with temporary cements

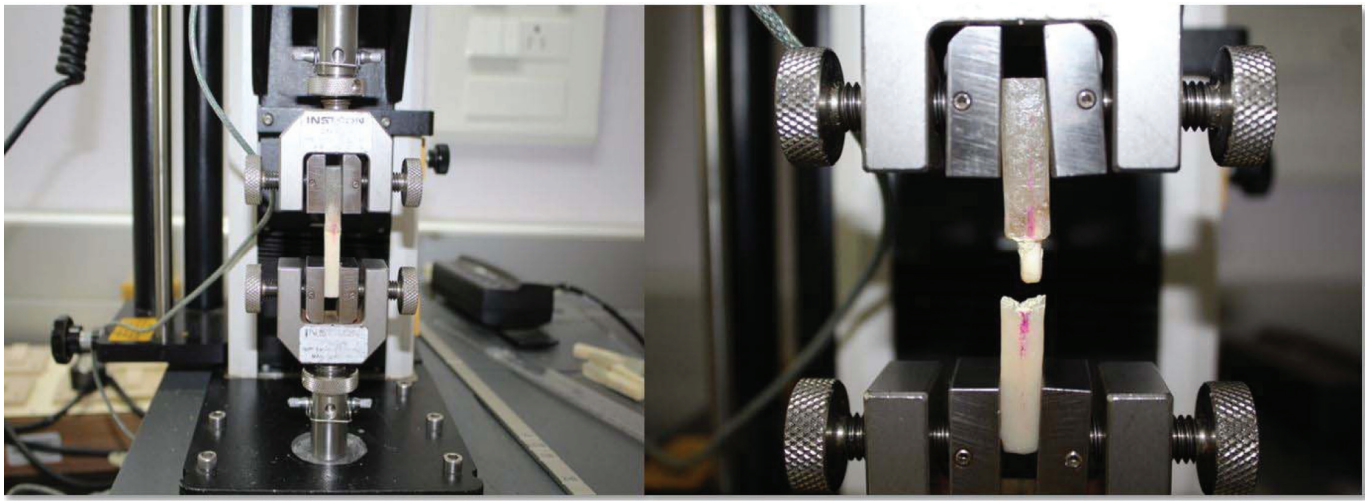

Figure 3: Bond strength testing using INSTRON 3345

Tukeys post hoc test for comparison between these groups at the significance level of ($p<0.05$)

Results:

The bond strength values of provisional PMMA crown to three different temporary luting cements were 6.37 MPa (zinc polycarboxylate), 3.39 MPa (zinc oxide eugenol free) and 4.40 MPa (zinc phosphate) respectively. One way ANOVA shows significant difference in the values among the groups ($p<0.05$) which shows that zinc polycarboxylate provides better bond strength compared with that of the zinc phosphate and zinc oxide eugenol free luting cement to PMMA temporary crowns. Tukeys Post Hoc test for comparison between these groups shows no significant difference in their values ($p = .00$) which shows high significant between the groups ($p<0.05$).

Discussion:

There is significant difference in the bond strength of three luting cements to heat cure PMMA crowns, hence null hypothesis is rejected.

Table 1: Mean and standard deviation values of all three temporary cements

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Maximum Load (N)	Zinc polycarboxylate	10	408.7550	23.22563	7.34459	392.1404	425.3696	375.19	458.80
	Zinc oxide eugenol free	10	238.3320	26.40349	8.34952	219.4441	257.2199	202.68	279.82
	Zinc phosphate	10	358.0820	12.47568	3.94516	349.1574	367.0066	339.24	378.19
	Total	30	335.0563	75.59024	13.8008	306.8305	363.2822	202.68	458.80
Load at Break (Standard) (N)	Zinc polycarboxylate	10	411.2260	20.91424	6.61366	396.2649	426.1871	378.04	445.41
	Zinc oxide eugenol free	10	229.7180	16.83025	5.32219	217.6784	241.7576	201.85	258.82
	Zinc phosphate	10	337.5090	12.17873	3.85125	328.7969	346.2211	318.51	357.48
	Total	30	326.1510	77.56681	14.1617	297.1871	355.1149	201.85	445.41
Tensile stress at Break (Standard) (MPa)	Zinc polycarboxylate	10	6.3780	.27900	.08823	6.1784	6.5776	5.91	6.76
	Zinc oxide eugenol free	10	3.3900	.14228	.04499	3.2882	3.4918	3.24	3.64
	Zinc phosphate	10	4.4060	.21706	.06864	4.2507	4.5613	3.93	4.67
	Total	30	4.7247	1.27942	.23359	4.2469	5.2024	3.24	6.76

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This in vitro study is done in the natural teeth to partly simulate the oral environment. There have been many studies in the literature[7,8] shows the bond strength of luting cements to different core materials, which is different from present study that compared the luting cements to provisional PMMA crown. These studies also does not simulate the oral environment. There are no studies regarding comparison of the bond strength of different temporary cements to provisional PMMA crowns.

In the present study, zinc polycarboxylate provides better bond strength compared with that of the zinc phosphate and non eugenol luting cement to PMMA temporary crowns. This result is similar to Reddy et al[9] and they reasoned that the polycarboxylates have a higher adhesive strength than zinc phosphate due to chemical reactions where zinc ions cross link with adjacent poly acrylic acid molecule. The poly acrylic acid molecules have the ability to chelate to calcium ions in tooth enamel as well as to stainless steel crown which supports our study with increased bond strength of zinc polycarboxylate to provisional PMMA crowns. It also shows that adhesive cements provide better bond strength due to its chemical adhesion to tooth structure compared with non adhesive cements.

In the present study, zinc oxide eugenol free is chosen in comparison with zinc oxide eugenol. The reason is during resin polymerization can be inhibited by any material that reacts with free radicals. Eugenol is a free radical scavenger, inhibiting polymerization either by a decrease in the rate of initiation or an increase in the rate of termination, which leads to increased surface roughness, reduced micro hardness, and color stability of resin composites cured in contact with ZOE cement. Nasreen et al,[10] in their study reported that eugenol causes release of calcium from dentin due to its complexing properties. This may have a softening effect on dentin. Inadequate polymerization coupled with softening of dentin

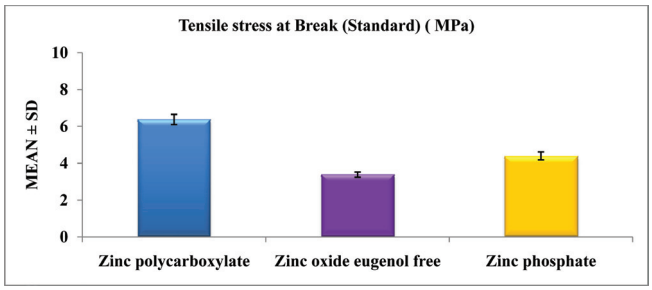

Figure 4 : Bond strength values of all three temporary cements

Table 2: One way ANOVA values of three temporary cements

		Sum of Squares	df	Mean Square	F	Sig.
Maximum Load (N)	Between Groups	153172.715	2	76586.357	165.031	.000*
	Within Groups	12529.952	27	464.072		
	Total	165702.666	29			
Load at Break (Standard) (N)	Between Groups	166660.833	2	83330.416	287.682	.000*
	Within Groups	7820.857	27	289.661		
	Total	174481.690	29			
Tensile stress at Break (Standard) (MPa)	Between Groups	46.164	2	23.082	476.900	.000*
	Within Groups	1.307	27	.048		
	Total	47.471	29			

*. The mean difference is significant at 0.05 level.

leads to decreased bond strength and increased microleakage, resulting in clinical complications, such as fractured restoration, hypersensitivity, secondary caries, and surface discoloration.

Limitations:

1. The study could be done in the artificial salivary environment to simulate the natural oral environment.

2. In this study, single operator manual finger pressure is applied which may vary from person to person, so we could have applied the pressure with help of load guiding gauge device which should imitate the human biting force at premolar area.

3. The future studies can be done to compare another Bi–acrylate provisional luting cement which limits this study by using single heat cure PMMA material.

Table 3- Post Hoc test-Multiple comparison values among three groups

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Maximum Load (N)	Zinc polycarboxylate	Zinc oxide eugenol free	170.42300*	9.63403	.000	146.5362	194.3098
		Zinc phosphate	50.67300*	9.63403	.000	26.7862	74.5598
	Zinc oxide eugenol free	Zinc polycarboxylate	-170.42300*	9.63403	.000	-194.3098	-146.5362
		Zinc phosphate	-119.75000*	9.63403	.000	-143.6368	-95.8632
	Zinc phosphate	Zinc polycarboxylate	-50.67300*	9.63403	.000	-74.5598	-26.7862
		Zinc oxide eugenol free	119.75000*	9.63403	.000	95.8632	143.6368
Load at Break (Standard) (N)	Zinc polycarboxylate	Zinc oxide eugenol free	181.50800*	7.61133	.000	162.6363	200.3797
		Zinc phosphate	73.71700*	7.61133	.000	54.8453	92.5887
	Zinc oxide eugenol free	Zinc polycarboxylate	-181.50800*	7.61133	.000	-200.3797	-162.6363
		Zinc phosphate	-107.79100*	7.61133	.000	-126.6627	-88.9193
	Zinc phosphate	Zinc polycarboxylate	-73.71700*	7.61133	.000	-92.5887	-54.8453
		Zinc oxide eugenol free	107.79100*	7.61133	.000	88.9193	126.6627
Tensile stress at Break (Standard) (MPa)	Zinc polycarboxylate	Zinc oxide eugenol free	2.98800*	.09839	.000	2.7441	3.2319
		Zinc phosphate	1.97200*	.09839	.000	1.7281	2.2159
	Zinc oxide eugenol free	Zinc polycarboxylate	-2.98800*	.09839	.000	-3.2319	-2.7441
		Zinc phosphate	-1.01600*	.09839	.000	-1.2599	-.7721
	Zinc phosphate	Zinc polycarboxylate	-1.97200*	.09839	.000	-2.2159	-1.7281
		Zinc oxide eugenol free	1.01600*	.09839	.000	.7721	1.2599

*. The mean difference is significant at the 0.05 level.

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Conclusion:

Within the limitations of this study, it is concluded that

1. Zinc polycarboxylate provides better bond strength compared with that of the zinc phosphate and non eugenol luting cement to PMMA temporary crowns.

2. Zinc phosphate showed higher bond strength compared with zinc oxide eugenol free cement.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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