Comparative evaluation of the shear bond strength of adhesive and self-adhesive resin luting agents to three commercially available composite core build-up materials: An *in vitro* study

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Abstract

Aim: The aim of the study was to evaluate the shear bond strength of adhesive and self-adhesive resin luting agents (RLAs) to three commercially available composite core build-up materials (CBMs).

Settings and Design: Comparative -*invitro* study.

Materials and Methods: Sixty samples, 20 each of self-cure (Incore, Medicept: Group I), light cure (Light-Core, Bisco: Group II), and dual cure (LuxaCore Z-Dual, DMG America: Group III) composite CBMs were made in the lower mold space of a customized stainless steel jig. They were further subdivided into subgroups A and B for bonding with the adhesive (RelyX Ultimate, 3M ESPE) and self-adhesive (RelyX Unicem, 3M ESPE) RLAs respectively. For specimens in subgroup A, the bonding agent (Scotchbond Universal Adhesive, 3M ESPE) was rubbed onto the surface for 20 s prior to bonding with the adhesive RLA. For specimens in subgroup B, no pretreatment of the surface was carried out. The CBM-luting agent sample was tested for the shear bond strength in a universal testing machine.

Statistical Analysis Used: ANOVA, Tukey's multiple comparison, and independent *t*-test.

Results: Adhesive RLA showed the highest shear bond strength to light cured composite CBM. Self-adhesive RLA showed the highest shear bond strength to dual-cured composite CBM. Adhesive RLA showed higher shear bond strength to all three composite CBMs as compared to the self-adhesive luting agent. This difference was statistically significant for the self-cure and light cure composite CBMs.

Conclusion: Adhesive RLA showed greater shear bond strengths to all the three groups of composite CBMs as compared to self-adhesive RLA.

Keywords: Composite core, core build-up materials, resin luting agent, shear bond strength

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INTRODUCTION

When the lost tooth structure is restored with a core build-up material (CBM), the bond strength between the CBM and the luting agent becomes significant for the retention, longevity, and esthetics of the restoration. Differences of the CBM can affect the bond strength of luting agents.[1] Adhesive luting agents allow for increased crown retention that is independent of preparation geometry.[2] Resin luting agents (RLA) are a popular choice because of their ability to adhere to multiple substrates, high strength, insolubility in the oral environment, and shade-matching potential.[3]

Adhesive RLA requires the use of an adhesive agent to condition the tooth surface or the surface of the composite core material prior to the cementation procedure. Self-adhesive RLA do not require any pretreatment of bonding surface prior to cementation procedure, thereby reducing the technique sensitivity.[4-6]

One of the reasons of failure of the indirect restorations is due to poor bond between the luting agent and the tooth/core material. Thus, this study was carried out to compare and evaluate the shear bond strength between adhesive and self-adhesive RLA to three composite CBM having different mechanisms of polymerization: self-cure, light cure, and dual cure.

MATERIALS AND METHODS

The materials used in the study are listed in Table 1.

Methodology

Preparation of the composite core build-up samples

A total of 60 samples were fabricated; 20 for each of the self-cure (Group I), light cure (Group II), and dual cure (Group III) composite CBM, using a customized stainless steel jig [Figures 1 and 2].

It had two metal plates with a sliding mechanism. The lower plate had a detachable sample holder with a mold space of diameter 5 mm and thickness 4 mm. This was movable in the vertical direction so as to contact the opposing plate, having a corresponding mold space of similar dimensions, and held in place with the help of a screw. Holes of smaller dimensions on the other side were used to engage rods for testing of samples in the universal testing machine.

Composite CBM discs were made in the lower mold space [Figure 3].

Table 1: List of materials used in the study

Group	Material	Brand Name
Group I	Self-cure composite core build-up material	Incore, Medicept
Group II	light cure composite core build-up material	Light- Core, Bisco
Group III	Dual cure composite core build-up material	LuxaCore Z- Dual, DMG America
Subgroup A	Adhesive RLA	RelyX Ultimate, 3M ESPE with Scotchbond Universal Adhesive, 3M ESPE
Subgroup B	Self-adhesive RLA	RelyX Unicem, 3M ESPE

RLA: Resin luting agents

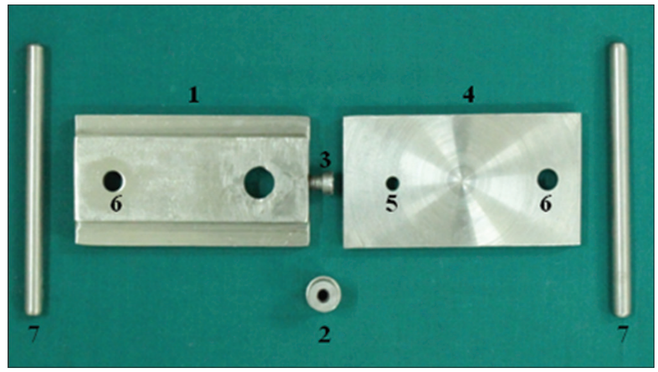


Figure 1: Parts of the jig. 1: Lower plate, 2: Detachable sample holder with lower mold space, 3: Screw, 4: Upper plate, 5: Upper mold space, 6: Holes for engaging rods, 7: Engaging rods

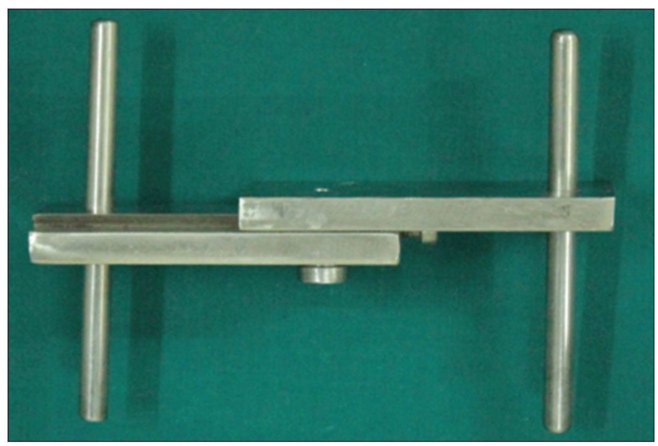


Figure 2: Side view of the assembled jig

Figure 3: Packing of the composite core build-up material in the lower mold space

Flushing of the composite core build-up samples with the sample holder

To simulate clinical treatment of cores, the excess material on the bonding surface was finished with a diamond finishing bur in an airotor handpiece [Figure 4]. A flat bonding surface with a uniform surface roughness for all the specimens was obtained, cleaned with air-water spray and dried with air for 10 s.

Division of the samples

Groups were further subdivided (*n* = 10) for bonding with adhesive and self-adhesive RLA into Subgroups A and B, respectively.

Application of the bonding agent

For specimens in Subgroup A, the bonding agent was rubbed onto the surface for 20 s, and a gentle stream of air was blown over the surface for 5 s [Figure 5].

For specimens in Subgroup B, no pretreatment of the surface was carried out.

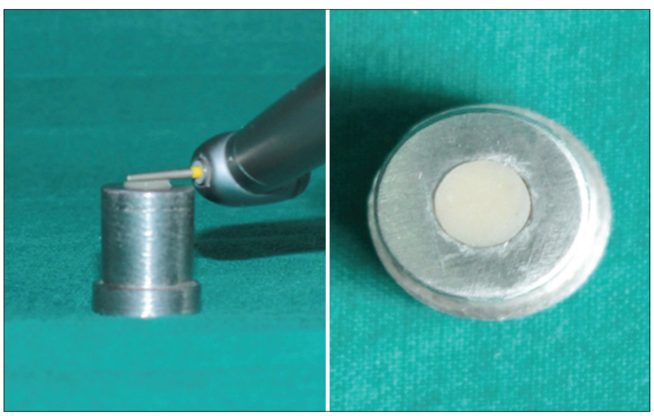


Figure 4: Composite core flushed to sample holder

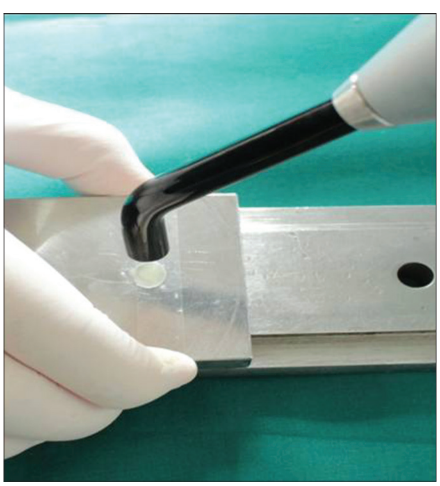


Figure 6: Alignment of the upper and lower mold spaces, adaptation of cellulose acetate strip and light curing of the resin luting agent

Preparation of the composite core build-up - luting agent samples

The jig was assembled, the sample holder raised to contact the upper plate so that the bonding surface lay at the interface of the upper and lower plates and the screw was tightened to secure it in this position. The respective RLA for the two groups was placed in the upper mold space and polymerized by light curing for 40 s [Figure 6].

Testing for shear bond strength in a universal testing machine

The samples were tested for the shear bond strength in a universal testing machine (cross-head speed: 5 mm/min, certified range: 0–1 kN, rate of increase of applied force: 0.05 kN) by sliding the two plates of the jig [Figure 7] until the sample fractured [Figures 8 and 9].

Null hypothesis

There is no difference in the shear bond strengths of adhesive and self-adhesive RLA to the self-cure, light cure, and dual-cure composite CBM.

Alternate hypothesis

There is a difference in the shear bond strengths of adhesive and self-adhesive RLA to the self-cure, light cure, and dual-cure composite CBM.

Figure 5: Application of bonding agent to samples in Group IA, IIA, and IIIA

Figure 7: Testing of the samples in a universal testing machine

RESULTS

The peak load at failure was recorded in Newtons (N), and shear bond strength in Megapascals (MPa) was calculated by dividing it by the surface area (mm^2) of the bonding surface. Since the diameter of the samples was 5 mm, the surface area was 19.643 mm^2.

Formula: $\sigma = F/A$; where, "σ"-bond strength (MPa), "F"-load required for specimen failure (N), "A"-adhesive area of the specimen (mm^2).

The mean shear bond strength in MPa for each group was calculated [Table 2 and Graph 1].

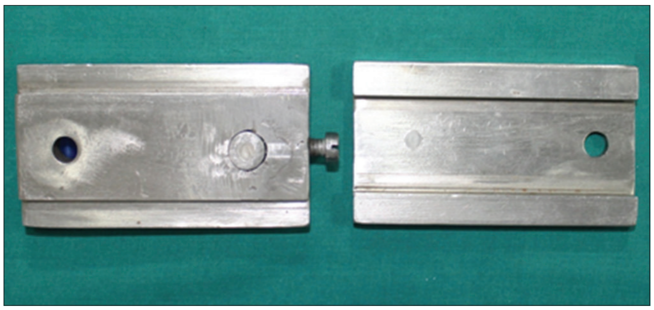


Figure 8: Fractured samples in the jig

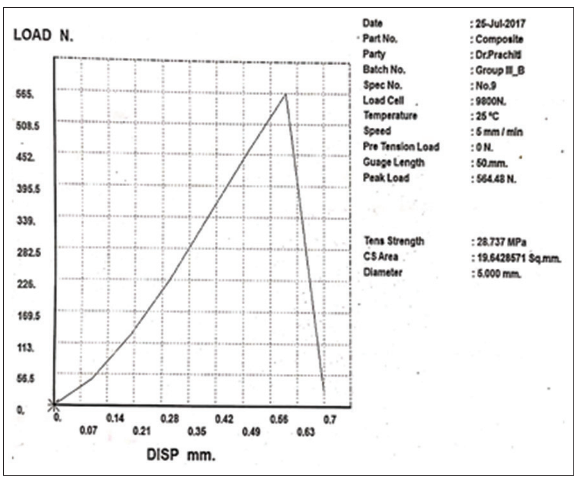
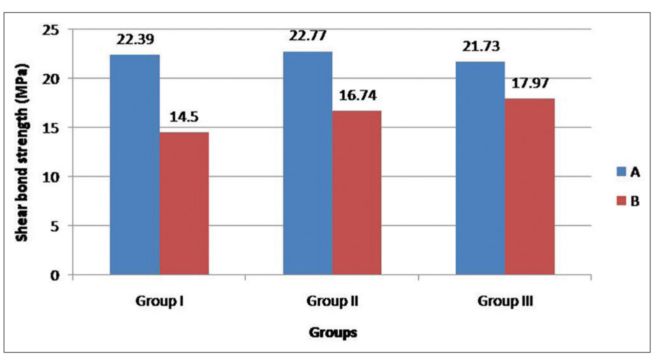


Figure 9: Failure curves produced for the sample



Graph 1: Graph showing the mean values of groups

Statistical analysis

On statistical analysis [Tables 3-6] using ANOVA, Tukey's multiple comparison, and independent *t*-test; since the *P* value for the *t*-test was <0.05, significant difference in the shear bond strengths was seen for Groups IA and IB and Groups IIA and IIB. Thus, the proposed null hypothesis was rejected, and the alternative hypothesis was accepted.

DISCUSSION

As self-adhesive RLA is becoming popular, more studies targeted at evaluating their bond strength when bonded to a variety of prosthodontic substrates are required.[1] No study comparing the shear bond strength of adhesive and

Table 2: Shear bond strength

Serial number	Shear bond strength (MPa)					
	Group I		Group II		Group III	
	A	B	A	B	A	B
1	23.92	11.96	21.07	16.86	27.94	13.30
2	21.57	12.72	23.26	13.78	18.30	14.89
3	18.01	15.46	24.69	14.21	21.06	22.40
4	23.09	13.91	21.65	13.42	19.90	17.41
5	19.95	15.06	19.95	22.89	12.87	16.16
6	22.35	15.51	21.25	16.82	20.85	12.07
7	25.29	15.36	17.84	16.61	27.93	22.15
8	23.94	15.86	26.14	21.35	22.14	18.06
9	20.00	16.46	25.04	12.22	19.89	21.52
10	25.79	12.72	26.89	19.29	26.47	21.80
Average	22.39	14.50	22.77	16.74	21.73	17.97

Table 3: Test of normality

	Groups	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	*P*	Statistic	df	*P*
Shear bond strength (Mpa)	Group IA	0.130	10	0.200*	0.961	10	0.796
	Group IIA	0.151	10	0.200*	0.964	10	0.830
	Group IIIA	0.166	10	0.200*	0.922	10	0.375
	Group IB	0.240	10	0.107	0.893	10	0.184
	Group IIB	0.187	10	0.200*	0.935	10	0.501
	Group IIIB	0.221	10	0.183	0.903	10	0.236

[a]Lilliefors Significance Correction, *This is a lower bound of the true significance. Interpretation: Since *P* value for the Kolmogorov–Smirnov test and Shapiro–Wilk test is >0.05, it indicates that data is normally distributed. Therefore, we used ANOVA to test the significance of the difference between groups

Table 4: ANOVA test

	Sum of squares	df	Mean square	*F*	*P*
For groups IA, IIA, IIIA					
Between groups	5.560	2	2.780	0.227	0.798
Within groups	330.711	27	12.249		
Total	336.271	29			
For groups IB, IIB, IIIB					
Between groups	62.050	2	31.025	3.124	0.060
Within groups	268.124	27	9.931		
Total	330.174	29			

Interpretation: Since *P* value for the ANOVA is >0.05; it indicates no significance of difference. To test the exact significance, Tukey's Multiple comparison test is used

Table 5: Tukey's multiple comparison test

Groups (I)	Groups (J)	Mean difference (I–J)	SE	*P*	Interpretation
For groups IA, IIA, IIIA					
Group IA	Group IIA	−0.38700	1.56516	0.967	Not significant
Group IA	Group IIIA	0.65600	1.56516	0.908	Not significant
Group IIA	Group IIIA	1.04300	1.56516	0.785	Not significant
For groups IB, IIB, IIIB					
Group IB	Group IIB	−2.24300	1.40929	0.266	Not significant
Group IB	Group IIIB	−3.47400	1.40929	0.052	Not significant
Group IIB	Group IIIB	−1.23100	1.40929	0.661	Not significant

Interpretation: P value <0.05, indicates significance of difference between the respective groups. SE: Standard error

Table 6: Independent *t*-test

	t-test	df	*P*	Mean difference	SE difference
Group IA and IB	8.444	18	0.000	7.88900	0.93423
Group IIA and IIB	4.170	18	0.001	6.03300	1.44665
Group IIIA and IIIB	1.957	18	0.066	3.75900	1.92046

Interpretation: Since P value for the independent t-test is less than that of 0.05 indicates significance of difference between Group IA and IB, and Group IIA and IIB. Since P value for the independent t-test is greater than that of 0.05 indicates no significance of difference between Groups IIIA and IIIB. SE: Standard error

self-adhesive RLA to self-cure, light-cure, and dual-cure composite CBM was carried out. Hence, this present study was undertaken.

A CBM is used to restore the bulk of the coronal portion of the tooth[7] and stabilize the weakened parts of the tooth.[8] It contributes to the strength of the preparation[9] and develops a favorable retention and resistance form of the preparation.[10] The biomechanical behavior of the remaining tooth structure and crown is influenced by the mechanical properties of the post and core.[11,12]

Cast post and cores, silver amalgam, glass ionomer, resin-modified glass ionomer, and composite resin are used as CBM.[13] Composite CBM is widely used and may be chemical, light, or dual-cured.[14] Their physical and handling properties may lead the clinician to favor one material over another.[10] Composite CBM representative of each of these groups was included to study their interaction with the luting agents.

Luting is the final step in the sequence of clinical procedure for indirect restorations. Several studies have demonstrated that luting agents improve the durability of restorations.[3,15,16] Composite resin core and resin cement combinations were superior to all other cement and core combinations tested in a study by Nayakar *et al.*[17] Thus, adhesive RLA with the recommended bonding agent was used in the present study. RLA with dentin bonding agents is recommended as the luting agents of choice for ceramic, metal, and indirect composite restorations[2,15] as they provide increased crown retention and fracture resistance of core/crown complex.[18]

Recently introduced self-adhesive RLA was aimed at simplifying the clinical procedures and eliminate the need for etching, priming, and bonding as separate steps.[19] Its multifunctional monomers with phosphoric acid groups simultaneously demineralize and infiltrate enamel and dentin.[20,21] Their bond strength to enamel was reported to be lower compared to conventional RLAs, whereas significant differences were reported in bonding to dentin.[22-26]

A customized stainless steel jig with a circular test interface designed by Hammad and Stein in 1990[27] was used to ensure a specific path, prevent possible rotation of samples during testing, direct stresses mainly at the metal-ceramic interface to ensure a uniform distribution of the shear forces across the bonding surface on account of its sliding mechanism.[27]

The results of the study showed that adhesive RLA showed significantly greater shear bond strengths to self-cured and light-cured composite CBM as compared to self-adhesive RLA. Similar results with light-cured restorative composite were observed in other studies.[19,28]

Compatibility between the resinous components in the matrix of luting agents and composite was partially responsible for the observed results. Solvents present in the adhesive systems may cause modification of the surface layer, enabling the monomer of the RLA to react with the nonconverted vinyl groups (−C=C) at the subsurface of the composite CBM.[29]

Adhesive RLA showed the highest shear bond strength to light-cured composite CBM followed by self-cured and dual-cured composite CBM, while self-adhesive RLA showed the highest shear bond strength to dual-cured composite CBM, followed by light cured and self-cured composite CBM. However, in the present study, a significant difference in the shear bond strength was not found within the different composite CBM groups.

Limitations of the study

Only a few combinations of the CBM and luting agents could be evaluated. Larger sample size could be taken. Further studies could be done on the tensile and compressive bond strengths of these materials.

CONCLUSION

1. Adhesive RLA showed the highest shear bond strength to light cured composite CBM. The difference in the shear bond strengths between groups IA, IIA and IIIA was not statistically significant
2. Self-adhesive RLA showed the highest shear bond strength to dual-cured composite CBM. The difference in the shear bond strengths between groups IB, IIB and IIIB was not statistically significant
3. Adhesive RLA showed significantly greater shear bond strengths to self-cured and light-cured composite CBM as compared to self-adhesive RLA.

Clinical significance

Interactions between the CBM, luting agent, and setting reaction have a significant effect on the bond strength. Luting agents are weakest in shear bond strength. Thus, it becomes imperative to evaluate their shear bond strengths to different substrates to ensure clinical longevity.

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Conflicts of interest

There are no conflicts of interest.

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