ORIGINAL RESEARCH

Assessment of Bond Strength Following Simultaneous Activation of Resin-modified Glass Ionomer and Self-etch Adhesive in Primary Molars: *In Vitro* Study

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Abstract

Aim: The aim of the study was to assess the bond strength following simultaneous activation of resin-modified glass ionomer (RMGI) base and self-etch adhesive in sandwich restoration compared to conventional sandwich restoration in primary molars.

Materials and methods: Thirty non-carious primary molars were embedded in acrylic up to the cementoenamel junction. The coronal portion of the teeth were removed using a diamond disk to obtain flat dentin surfaces for standardization and allocated randomly to three different groups: group I—simultaneous activation of RMGI and self-etch adhesive (SAT); group II—simultaneous activation of RMGI and self-etch adhesive with enamel etching (SAT+EE); and group III—conventional sandwich technique (ST). All groups were then restored with bulk fill composite. The samples were stored in distilled water for 24 hours at room temperature and evaluated for shear bond strength under universal testing machine until failure.

Results: The mean shear bond strength of group I was 1.40, group II was 3.10, and group III was 1.71. Analysis of variance (ANOVA) test results revealed statistically significant difference between the groups ($p < 0.0001$). Tukey's *post-hoc* analysis revealed a highly statistically significant difference between group I and group II ($p < 0.0001$). The difference between group II and group III was also significant ($p < 0.001$). Mean time taken was least for SAT group (70 seconds) followed by SAT+EE group (85 seconds) and the maximum time taken was for ST group (100 seconds). One-way ANOVA test suggested a statistically significant difference between the groups ($p < 0.0001$). *Post-hoc* analysis showed a statistically significant difference between group I and group II ($p < 0.001$) and group I and group III ($p < 0.0001$).

Conclusion: Simultaneous activation technique with selective EE resulted in a greater bond strength as compared to that of without etching or the conventional technique.

Clinical significance: This technique may provide better retention and longevity of the restoration. It involves less number of steps and is a time-saving procedure which can be beneficial for pediatric patients.

Keywords: Bond strength, Resin-modified glass ionomer, Selective enamel etching, Simultaneous activation technique.

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Introduction

Sandwich restoration is a commonly used technique in primary teeth where resin composite is placed over a glass ionomer (GI) base. However due to disadvantages of conventional GI such as prolonged setting time and moisture sensitivity, a weak bond strength is obtained between the resin composite and GI.[1,2] To counter these disadvantages, use of RMGI as base has been investigated in sandwich restorations. Studies have shown improved bonding with composites, lesser moisture sensitivity, and a decreased working time with RMGI base.[3] According to Subrata and Davidson, in conventional sandwich restoration, etching of the GI base was recommended to increase the bond strength between the resin composite and the GI base.[4] However, there is no consensus, regarding the need for etching of RMGI to increase the bond strength.

Self-etch adhesives are the new generation bonding agents that do not require acid etching and rinsing procedures to be performed separately, reducing the chairside time. Previous studies have established that self-etch adhesives when used in primary teeth show good sealing ability.[5,6] In a study carried out by Boruziniat and Gharaei, self-etch adhesives when used in sandwich restoration showed greater bond strength between the resin composite and the RMGI.[7]

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Pinheiro et al. proposed that SAT, where RMGI and adhesive are polymerized together in a sandwich restoration, has shown to increase the bond strength between resin composite and RMGI.[8]

Extensive search of literature however revealed inconclusive evidence on effect of simultaneous activation of RMGI and self-etch adhesive on the bond strength in a sandwich restoration in primary teeth. Hence, the purpose of this study was to assess the bond strength evaluating the SAT as a modified sandwich restoration procedure in primary teeth.

Materials and Methods

This study was conducted in the Department of Pedodontics and Preventive Dentistry, School of Dentistry, DY Patil University, Navi Mumbai. Institutional review board approval was obtained before beginning the study (IREB/2022/PEDO/01). The sample size was calculated based on the empirical formula and a total of 30 teeth were selected. Ten teeth per group was considered. Non-carious primary molars extracted for the purpose of eruption guidance or orthodontic reasons were selected for the study. Teeth with developmental enamel defects or cracks or teeth showing complete resorption of roots were excluded.

Specimen Preparation and Restoration

The following procedures were carried out by a single investigator. Selected extracted teeth were cleaned off any soft tissue or debris with an ultrasonic scaler[9] followed by prophylaxis with a rubber cup and pumice slurry.[10] Teeth were washed with distilled water and stored in 0.1% thymol solution at room temperature for up to 1 month, in order to preserve the microhardness of enamel and dentin.[2,11,12] Thereafter, they were embedded in acrylic up to the cementoenamel junction.[13] The coronal portion of the teeth were removed using a diamond disk to obtain flat dentin surfaces for standardization.[14,15] Primer (Vitremer™—3M) was then applied with a brush for 30 seconds to the tooth and air-dried followed by light curing for 20 seconds. This was done to modify the smear layer and adequately wet the tooth surface and facilitate adhesion of RMGI.[16] Teeth were then randomly divided into three groups:

1. Group I—simultaneous activation technique (SAT)
2. Group II—simultaneous activation technique+enamel etching (SAT+EE)
3. Group III—conventional sandwich technique (ST)

In group I (SAT), RMGI (Vitremer™ Tri-Cure Glass Ionomer System—3M) powder and liquid were dispensed and mixed according to the manufacturer's instructions. The material was applied on the dentin surface using a plastic placement instrument, so that the thickness of the RMGI base was approximately 1 mm. This base was not cured. Self-etch adhesive (Adper™ Easy Bond—3M) was immediately applied onto the base and was light cured (30 seconds). Resin composite (Z250 Xt Composite—3M) was placed using bulk fill technique and was cured (40 seconds). In group II (SAT+EE), RMGI base of 1 mm thickness was applied and was not cured. Self-etch adhesive was immediately applied onto the base and was light cured (30 seconds) similar to group I. Then an additional step of selective etching of the enamel was carried out with phosphoric acid (15 seconds), washed with air water spray followed by placement of resin composite using bulk fill technique and cured (40 seconds). In group III (ST), RMGI base of 1 mm thickness was applied and was light cured (30 seconds). Self-etch adhesive was applied onto the base and light cured (30 seconds), followed by placement of resin composite using bulk fill technique and cured (40 seconds). The total thickness of the restoration in each specimen was 4 mm. Following treatment with respective groups, the specimens were stored in distilled water at 37°C for 24 hours to prevent any dehydration changes in dentin/material that could affect bond strength.

Shear Bond Strength Test

The specimens were then secured to the jig of the universal testing machine, stressed in tension at a crosshead speed of 1 mm per minute until bond failure.[9] The maximum stress at failure was recorded and converted to megapascal units (MPa).

Statistical Analysis

All data were entered into a Microsoft Office Excel (Office version 365) in a spreadsheet and checked for errors and discrepancies. Data analysis was done using IBM SPSS Statistics 20.0 (IBM Corporation, Armonk, NY, USA) and data were generated. Analysis of variance was used to find the significance of study parameters between the groups (inter group analysis). Tukey's *post- hoc* analysis was carried out. Results on continuous measurements were presented on mean ± SD. Level of significance was fixed at $p = 0.05$ and any value less than or equal to 0.05 was considered to be statistically significant.

Results

The mean shear bond strength of group I—SAT was 1.40, group II—SAT+EE was 3.10, and group III—ST was 1.71 (Table 1). According to one-way ANOVA test, there was a statistically significant difference between the groups ($p < 0.0001$) (Table 2). *Post-hoc* analysis showed there was statistically significant difference between group I and group II ($p < 0.0001$) as well as between group II and group III ($p < 0.001$) but no significant difference was seen between group I and group III (Table 3). Mean time taken was least for SAT group (70 seconds) followed by SAT+EE group (85 seconds) and the maximum time taken was for ST group (100 seconds). One-way ANOVA test suggested a statistically significant difference between the groups ($p < 0.0001$) (Table 4). *Post-hoc* analysis showed a statistically significant difference between group I and group II ($p < 0.001$) and group I and group III

Table 1: Mean and standard deviation of shear bond strength

	SAT	*SAT+EE*	*ST*	*Total*
N	10	10	10	30
Mean	1.40	3.10	1.71	2.07
Std. deviation	0.83	0.83	0.59	1.05
Std. error	0.26	0.26	0.19	0.19
95% CI				
Lower	0.80	2.51	1.28	1.68
Upper	1.99	3.69	2.13	2.46
Minimum	0.87	2.21	0.84	0.84
Maximum	3.55	4.40	2.83	4.40

Table 2: One-way ANOVA test for shear bond strength

	Sum of squares	*Degree of freedom*	*Mean square*	*F*	*Sig.*
Between groups	16.490	2	8.24	14.395	<0.0001
Within groups	15.464	27	0.57		
Total	31.954	29			

Table 3: *Post-hoc* Tukey's test for shear bond strength

		Mean difference (I-J)	*Std. error*	*p*	*95% CI*	
					Lower	*Upper*
SAT+EE	SAT	1.705	0.338	<0.0001	0.866	2.544
	ST	1.394	0.338	0.001	0.555	2.233
SAT	SAT+EE	–1.705	0.338	<0.0001	–2.544	–0.866
	ST	–0.311	0.338	0.633	–1.150	0.528
ST	SAT+EE	–1.394	0.338	0.001	–2.233	–0.555
	SAT	0.311	0.338	0.633	–0.528	1.150

Table 4: One-way ANOVA for time (seconds)

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Between groups	3196.485	2	1598.242	61.828	<0.0001
Within groups	1628.545	63	25.850		
Total	4825.030	65			

Table 5: *Post-hoc* Tukey's test for time (seconds)

		Mean difference (I-J)	*Std. error*	*p*	*95% CI*	
					Lower	*Upper*
SAT+EE	SAT	6.000	1.533	0.001	2.320	9.680
	ST	–10.818	1.533	<0.0001	–14.498	–7.139
SAT	SAT+EE	–6.000	1.533	0.001	–9.680	–2.320
	PC	–16.818	1.533	<0.0001	–20.498	–13.139
ST	SAT+EE	10.818	1.533	<0.0001	7.139	14.498
	SAT	16.818	1.533	<0.0001	13.139	20.498

CI, class interval; ST, conventional sandwich technique

($p < 0.0001$) (Table 5). According to these results the bond strength was significantly better with SAT+EE group with less procedural time as compared to conventional restorative technique.

Discussion

Pinheiro et al. reported that modified sandwich restoration along with SAT (where the RMGI and adhesive are cured together) had shown to increase the bond strength in primary teeth.[8] However, not much research has been found in this aspect. Hence, the aim of this study was to evaluate the bond strength using this technique and compare it with the conventional ST.

Literature suggests that RMGI is considered to be better than conventional GI.[17,18] Previous studies comparing light cure GI base with conventional GI base in bovine and human teeth has revealed that better bond strength was seen with light cure GI base as compared to conventional GI base even after 7 months of storage in water.[19] Somani et al. compared the shear bond strength of three types of GIs (conventional type II GI, light cure GI, and type IX GI) in primary teeth and it was seen that light cured GI showed the maximum bond strength to dentin.[20] Hence, in our study, RMGI was considered as a base for the restorative procedures.

Self-etch adhesives are the generation of bonding agents which have been considered to have less postoperative sensitivity and are less technique sensitive due to the less number of procedural steps.[21] However, in a study done by Donmez et al., clinical performance of composite restorations placed with different adhesive systems was assessed in primary teeth. Three-step etch-and-rinse (group 1), two-step etch-and-rinse (group 2), two-step self-etch (group 3), and one-step self-etch (group 4) adhesives were compared. Better marginal adaptation was found in composite restorations made with etch-and-rinse adhesive systems than with self-etch adhesives. Hence, it was concluded that pre-etching of the primary enamel might help improve the clinical performance of the self-etch adhesive systems in primary teeth. In an *in vitro* study by Kim et al., the bond strengths of one-step self-etch adhesives applied to primary tooth dentin with and without additional acid etching was evaluated. It was seen that self-etch adhesives when etched showed higher bond strength as compared to the un-etched teeth. It was thus concluded that acid etching prior to application of self-etch adhesives improved the bond strength of the teeth.[22] Hence, in this study selective etching of the enamel was done and results were evaluated along with self-etch adhesives.[23]

Bulk fill composite technique is an advanced technique where manufacturers recommend 4- or 5-mm increments of composites in contrast to the maximum 2 mm increments recommended for conventional resin composites.[24] This technique helps in saving the restorative time and may thus be essential in young uncooperative patients.

Shear bond strength was assessed since it is a simple evaluation procedure to test the adhesion of dental adhesives. *In vitro* bond

strength tests are useful and essential for predicting the performance of adhesive systems and correlation with clinical issues.[25]

Simultaneous activation technique is a newer sandwich restorative technique where in RMGI and the adhesive are cured together before the placement of the composite.[8] According to the results of this study, maximum bond strength was obtained in the SAT+EE group (6 steps) followed by ST group (7 steps) and SAT group (5 steps). The difference between ST groups as compared to SAT was not statistically significant. If the etching and curing time taken for the above groups were examined, SAT group took least time (70 seconds) followed by SAT+EE (85 seconds) and ST (100 seconds). So considering the number of procedural steps and time, SAT could help in reducing chairside time which would be a beneficial substitute for treating pediatric patients.

In the present study, with an additional step of EE, it was noted that there was a significant increase in the bond strength of the restorations in SAT+EE group ($p < 0.0001$). Hence, EE could be beneficial for increasing the bond strength of the restoration. So SAT along with EE could be recommended as a restorative regime in primary teeth and further studies should be carried out to access these results in clinical situations.

Limitations

This is the first study to assess the bond strength using the SAT comparing group with and without etching. As not much data are available to compare this study. Further, clinical studies need to be carried out for comparison.

Conclusion

Conventional sandwich technique and SAT did not show any significant difference in the bond strength. Simultaneous activation technique can thus cause a reduction in the number of steps without any decrease in the clinical acceptability of the restoration. However, EE along with SAT showed a highly significant increase in the bond strength, hence, it can be concluded that SAT as a modified sandwich restoration with EE could be used in primary teeth and can be an important and time-saving procedure in children.

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