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# Comparison of shear bond strength of composite resin, compomer, and resin-modified glass-ionomer cements in primary teeth: An *in-vitro* study

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## Abstract

**OBJECTIVE:** The contemporary esthetic restorative materials such as composite resin and glass-ionomer cements and their modifications have all been developed keeping in mind the requirements of permanent teeth. There have been plenty of studies that have focused on the characteristics of these materials in relation to permanent teeth with a relative dearth of such studies as regard to the primary teeth. The present study was undertaken to compare and evaluate the shear bond strength of composite resin, compomer, and resin-modified glass-ionomer cements in primary teeth.

**METHODS:** Thirty non-carious primary molars that were indicated for extraction because of physiological resorption or, for orthodontic reasons, were selected. The selected teeth were randomly allocated to three groups of 10 each for composite, compomer, and resin-modified glass-ionomer cements. The enamel from the occlusal surface of all teeth was removed to expose the superficial dentin and was wet polished with 400 grit sand paper. Composite, compomer, and resin-modified glass-ionomer stubs were bonded on to the occlusal surfaces using a plastic tube as a template. All samples were, then, subjected to thermocycling and evaluation of shear bond strength using the universal testing machine at a cross-head speed of 0.5 mm/min, whereas the results obtained were subjected to statistical analysis. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA), whereas one-way analysis of variance (ANOVA) and Tukey's multiple post-hoc procedures were used for statistical analysis. A $P < 0.05$ was considered statistically significant.

**RESULTS:** The mean shear bond strength values for Groups I, II, and III were found to be $11.7 \pm 3.07$ MPa, $7.74 \pm 4.16$ Mpa, and $4.43 \pm 2.08$ Mpa, respectively, whereas one-way ANOVA and Tukey's multiple post-hoc procedures indicated that there were remarkable differences among the three groups with the results being statistically significant ($P < 0.05$).

**CONCLUSIONS:** Composite resin showed the highest shear bond strength in relation to primary dentin when compared to compomer and resin-modified glass-ionomer cements.


**Keywords:**

Compomer, composite resin, *in-vitro* study, primary teeth, resin-modified glass-ionomer cements, shear bond strength

## Introduction

Restoration of primary teeth has continued to be an important facet of restorative dentistry.[1] This becomes significant not only for the overall development and a healthy psyche of the child but also for the physiological development of permanent dentition,



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avoiding premature loss of teeth following extractions or, early exfoliations of primary teeth from gross decay, leading to problems of space closure.[2] Traditionally, posterior primary teeth with occlusal and proximal surface caries have been restored with silver amalgam, which was the only possibility in the yesteryears.[1] The high failure rate, especially, in class II restorations, and the logic behind the use of amalgam because of its mercury content have been some of the major constraints for the limitation of its usage in primary teeth. This becomes more obvious when, today, there are various alternatives available in contemporary dental practice.[3] Increased attention to the practice of minimal intervention dentistry combined with an increased awareness of esthetics has created the need for search of all newer restorative materials when treating dental caries in primary teeth.[2] At the same time, community concerns over dental amalgam have, also, prompted parental requests for alternative materials. In a similar context, in 1999, the National Health and Medical Research Council, Australia, recommended clinicians use alternatives to amalgam "when appropriate."[4] Recently, there has been an expansion in the range of tooth-colored, esthetic restorative materials available for restoring primary and young mixed dentitions including the all-new composite resin, the polyacid-modified composites (compomers), and the improved conventional as well as resin-modified glass-ionomer cement as against the previous choices of amalgam and stainless steel crowns.[3] To date, there have been no consistent guidelines developed in the pediatric dental literature regarding the material selection for restorative purposes, and the selection of the material has always been purely an individual choice of the clinicians.[4] The demands made of restoration in primary dentition are somewhat different from those in permanent dentition. This is due in part to the limited life span of primary teeth themselves the variable levels of cooperation by child patients and the morphology of the primary teeth.[5] Some of these demands have been satisfied by the esthetic materials such as composite resin and the improved glass-ionomer cement and their modifications; however, all these materials have basically been developed keeping in mind the requirements of permanent teeth. There have been plenty of studies that have focused on the characteristics of these materials in relation to permanent teeth though there has been a relative dearth of such studies as regards primary teeth. The present study was planned with a similar intent to compare and evaluate the shear bond strength of composite resin, compomer, and resin-modified glass-ionomer cement in primary teeth. The aim of the present study was to determine the best available restorative material suited for primary teeth in terms of shear bond strength.

## Materials and Methods

Thirty non-carious primary molars that were indicated for extraction because of physiological resorption or, for orthodontic reasons, were selected for the present study. The objectives and need for the study were approved by the Institutional Ethics and Review Board via. Letter approval no. SDDC/IERB/01-47-2022 before the start of the study. The extracted teeth were stored in distilled water at room temperature until further use. The selected teeth were, then, randomly allocated to three groups of 10 each, Group I, II, and III, mounted in cold cure acrylic resin in rectangular form with color coding for easy identification with Group I for composite resin (Ceram-X, Dentsply) mounted in yellow acrylic resin, Group II for compomer (Dyract, Dentsply) mounted in pink acrylic resin, and Group III for resin-modified glass-ionomer cement/resin-modified GIC (Fuji II LC, GC Corp.) mounted in red acrylic resin. The occlusal surfaces of all teeth were grounded with a diamond abrasive to expose superficial dentin, whereas the exposed surfaces were wet polished to smoothen with 400 grit sandpaper. The occlusal surfaces of Group I (composite resin) samples were air dried and the etchant was applied for 8 s, following which the etchant was rinsed-off with water for 20 s under running water and the surfaces were air dried using a three-way syringe. The etching was confirmed by the white frosty appearance of the treated surfaces. The dentin bonding agent was applied with the help of an applicator tip and light cured for 20 s. The composite resin was, then, dispensed with the help of a Teflon-coated plastic filling instrument and placed on to the tooth surface with the help of a plastic tube of 3.5 mm internal diameter and 4 mm height, which acted as a template, and light cured for 40 s in increments of 1.8 mm at a time as recommended by the manufacturers [Figure 1a-f]. Likewise, a similar protocol was followed for the selected teeth in Group II (compomer) samples, whereas compomer was used in place of composite as in the case of Group I samples [Figure 2a-f]. The occlusal surfaces of Group III (resin-modified glass-ionomer cement) samples were conditioned with a dentin conditioner for 10 s, which was, then, rinsed off with water for 30 s under running water, whereas the surfaces were blot dried with the help of cotton pellets. The powder and liquid were dispensed onto the mixing pad and manipulated as per the manufacturer's instructions and placed onto the occlusal surfaces with the help of a similar plastic tube, which was used in the case of Group I and II samples [Figure 3a-f]. The prepared samples were mounted in cold cure acrylic resin in rectangular form (Group I samples were mounted in yellow acrylic resin for composite resin, Group II samples were mounted in pink acrylic resin for compomer, and Group III samples were mounted in red acrylic resin for

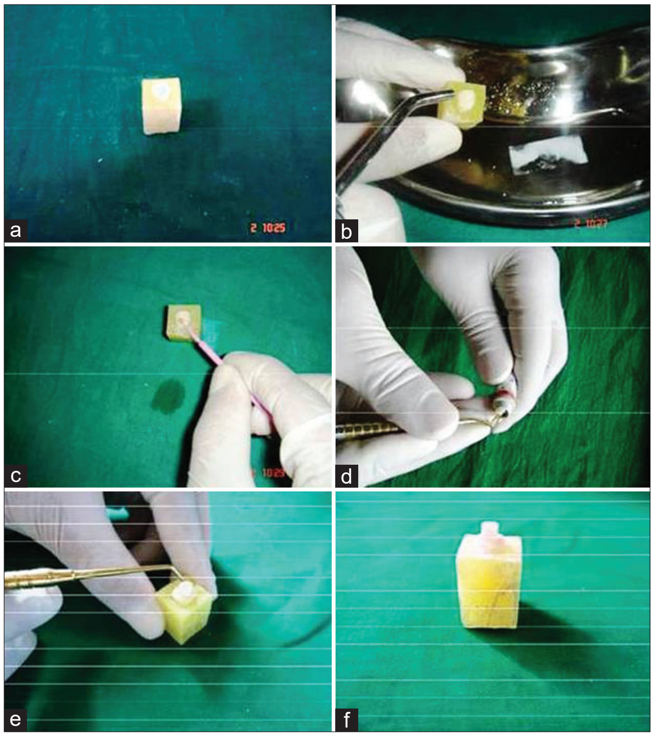


**Figure 1:** (a-f) Acid etching of Group I (composite resin) specimens, rinsing-off of the etchant, application of the bonding agent, dispensing of composite resin, placing the composite resin on the prepared tooth structure, completed specimen

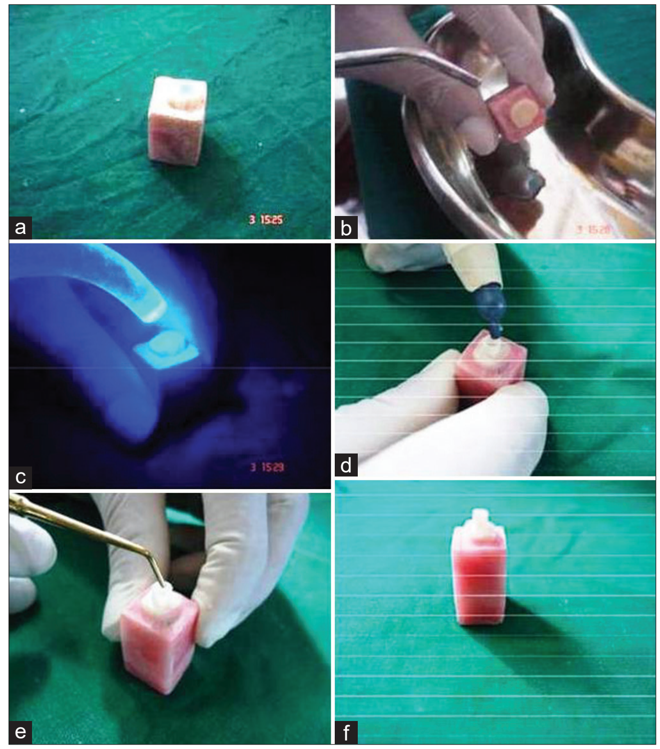


**Figure 2:** (a-f) Acid etching of Group II (compomer) specimens, rinsing-off of the etchant, application of the bonding agent followed by light curing, dispensing the compomer, placing the compomer on the prepared tooth structure, completed specimen

resin-modified glass-ionomer cement/resin-modified GIC) were assembled for further procedures [Figure 4]. The plastic tubings were, then, stripped off after light curing with a scalpel blade and BP handle (named after Charles Russell Bard and Morgan Parker, founders of the Bard-Parker Company) [Figure 5]. All samples were stored in distilled water for 24 h at room temperature and were, then, subjected to thermocycling in a water bath at 5 ± 2°C and 55 ± 2°C for 200 cycles with a dwell time of 30 s [Figure 6]. Bishara *et al*.[6] stated that "the purpose of thermocycling is to subject the teeth to temperature changes that may occur in the oral cavity." The samples were, then, subjected to shear bond strength testing using the universal testing machine (Shimadzu Co., Kyoto, Japan). Acrylic blocks containing the samples were secured to the platform with the composite, compomer, and resin-modified glass-ionomer cement rods oriented perpendicular to the direction of the cross-head travel. A knife edge was attached to the cross-head and aligned so that the point of contact was as near to the adhesive-dentin junction as possible. The cross-head speed was fixed at 0.5 mm/min. The maximum load to failure was recorded for each sample [Figure 7], whereas the shear bond strength (SBS) values were calculated as SBS = $P/\pi r^2$, wherein P represented the load and r represented the subjected sample's radius. The results obtained were subjected to statistical analysis.

Formula to calculate sample size:

Two means-hypothesis testing for two means (equal variances)

Standard deviation in the 1st group S1 = 3.01

Standard deviation in the 2nd group S2 = 2.05

Mean difference between 1st and 2nd samples = 3.21

Effect size = 1.26877470355731

Alpha error (%) = 5

Power (%) = 80

Sided = 2

Number needed ($n$) =10 in each group.

## Statistical analysis used

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA), whereas one-way analysis of variance (ANOVA) and Tukey's multiple post-hoc procedures were used for statistical analysis. $P < 0.05$ was considered statistically significant.

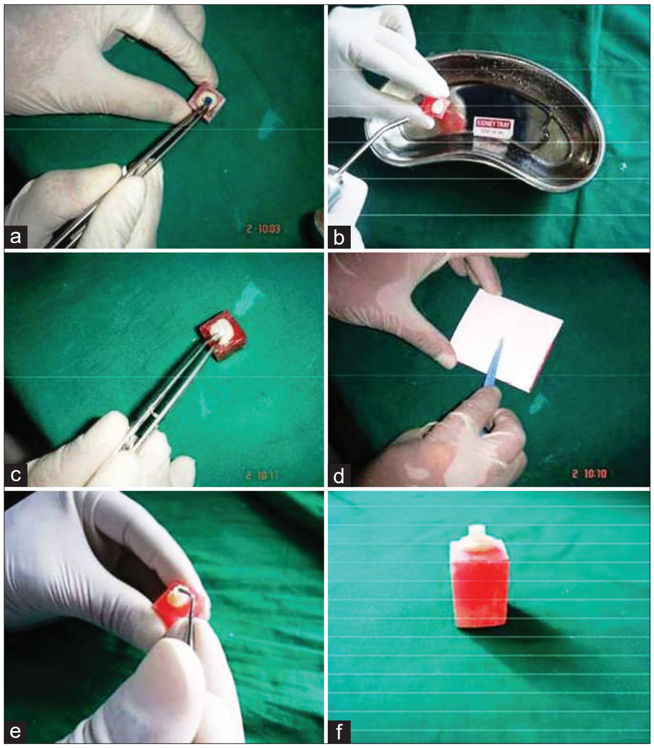



**Figure 3:** (a-f) Application of dentin conditioner in case of Group III (resin-modified glass-ionomer cement) specimens, rinsing-off of the dentin conditioner, blot drying of the prepared dentin surface, mixing of the resin-modified glass-ionomer cement, placing resin-modified glass-ionomer cement on the prepared tooth structure, completed specimen

**Figure 5:** Stripping-off of plastic tubing of completed specimens

## Results

In the present study, 30 non-carious freshly extracted primary molars were randomly divided into three groups of 10 each, Group I, Group II, and Group III ($n$ = 10). Composite resin was used in Group I, compomer in Group II, whereas resin-modified glass-ionomer cement was used in Group III. The results of the shear bond strength values derived for all three groups were

**Figure 4:** Completed specimens for the evaluation of shear bond strength

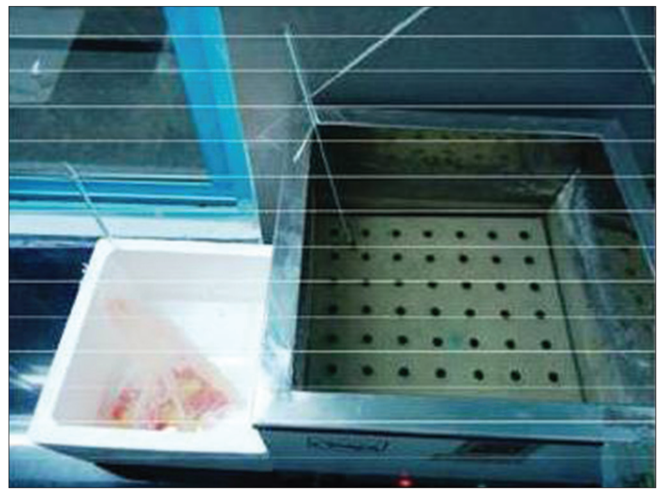


**Figure 6:** Thermocycling in a water bath at 5 ± 2°C and 55 ± 2°C

tabulated in Mega Pascals (Mpa). The mean and the standard deviations were calculated by descriptive statistics, whereas the intergroup comparisons were performed with the help of one-way ANOVA and Tukey's multiple post-hoc procedures using Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA). The $P$-value was taken as significant when less than 0.05. In the present study, Group I samples showed the highest shear bond strength (11.7 ± 3.07 MPa), followed by Group II (7.74 ± 4.16 MPa) and Group III (4.43 ± 2.08 MPa) [Table 1 and Graph 1]. Furthermore, pair-wise comparisons by Tukey's multiple post-hoc procedures revealed the differences between the mean shear bond strength values in between the groups to be statistically significant when compared between Group I and Group II ($P$ = 0.0273) and Group I and Group III ($P$ = 0.0001), though insignificant when compared between Group II and Group III ($P$ = 0.0729) despite showing significant variations in the mean shear bond strength values obtained in the said groups. From the above results, it was inferred that in primary dentition, on comparison of the mean shear bond strength values of composite resin, compomer, and resin-modified glass-ionomer cement, composite resin showed the highest mean shear

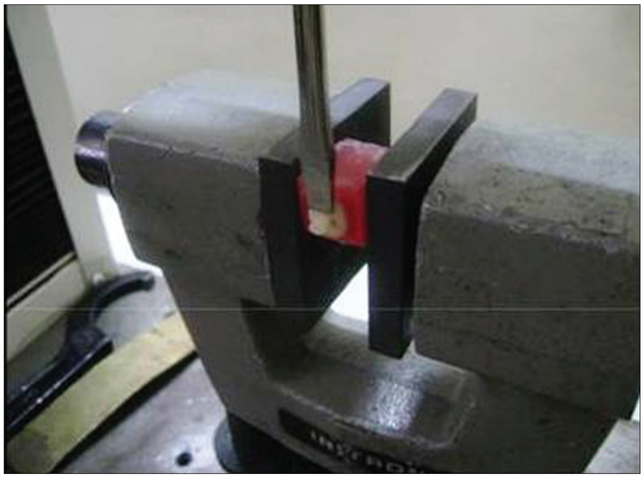


**Figure 7:** Specimens subjected to shear bond strength evaluation using the universal testing machine

**Table 1: Comparison of three groups (I, II, and III) with mean shear bond strength (in MPa) in primary teeth by one-way ANOVA**

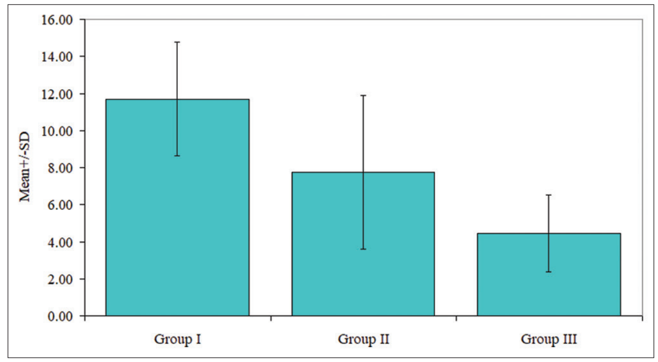
| Group | *n* | Range | Min. | Max. | Mean | Std. deviation |
|---|---|---|---|---|---|---|
| Group I | 10 | 9.37 | 8.61 | 17.9 | 11.7 | 3.07 |
| Group II | 10 | 11.7 | 2.52 | 14.2 | 7.74 | 4.16 |
| Group III | 10 | 5.76 | 1.8 | 7.57 | 4.43 | 2.08 |
| *F* | | | | 12.7976 | | |
| *P* | | | | 0.0001* | | |
| Pair-wise comparisons by Tukey's multiple *post-hoc* procedures | | | | | | |
| Group I vs. Group II | | | | *P*=0.0273* | | |
| Group I vs. Group III | | | | *P*=0.0001* | | |
| Group II vs. Group III | | | | *P*=0.0729 | | |

*$P<0.05$-statistically significant

bond strength (11.7 ± 3.07 MPa), which was significantly higher when compared to compomer (7.74 ± 4.16 MPa) and resin-modified glass-ionomer cement (4.43 ± 2.08 MPa), and the difference was found to be statistically highly significant ($P = 0.0001$) [Table 1].

## Discussion

Many dental adhesive restorative materials are available in the market these days. Almost all restorative materials available today are formulated keeping in mind the requirement of permanent teeth. The restoration of primary teeth in terms of restorative materials used has been neglected for long. The rapid spread of decay, enamel thinness, characteristic pulpal anatomy, and the small tooth size of the primary teeth make restorative treatments of primary teeth even more challenging. An effective bond of the restorative materials to enamel and dentin of primary teeth would preserve the tooth structure and allow for the esthetic and durable restorations in these teeth as well.[7] Shear bond




**Graph 1:** Comparison of three groups (I, II, and III) with mean shear bond strength (in MPa) in primary teeth

strength testing is frequently employed to evaluate the bond strength of the restorative materials to the tooth structure.[8] A possible advantage of testing shear bond strength is that this method is easy to perform when compared to testing the microtensile strength of restorative materials.[9] Moreover, shear stress is considered to be more representative of the actual clinical situation these restorative materials get subjected to post-restoration.[10]

Bonding to dentin remains more difficult than bonding to enamel. Dentin is a heterogeneous structure that varies according to its type and topographical location in the tooth, distance from the amelodentinal junction, the nature of trauma, and clinical experience before extraction. In addition, bonding to primary dentin is even more difficult due to its unique microstructure and chemical nature.[7] Also, the laboratory techniques utilized to bond and subsequently break the specimens affect the bond strength results. The method by which the bond is achieved, the method of placing the restorative material, bulk placement as opposed to incremental build-up, application of pressure, rate of load application, the length of time that the bonded units are stored in water and the use of thermocycling, all play a vital role in the final bond strength achieved.[7] To our knowledge, numerous studies have been conducted evaluating the bond strength of two different types of cement in primary teeth or, among the different brands of the same cement, though there is a relative lack of such studies that have compared the shear bond strength of the tested three types of restorative materials including composite resin, compomer, and resin-modified glass-ionomer cement in primary teeth. In the present *in-vitro* study, the shear bond strength of composite resin, compomer, and resin-modified glass-ionomer cement, which are the most commonly used tooth-colored, esthetic restorative materials in primary teeth, especially, in the case of early childhood caries (ECC), where it is very much challenging to rebuild the lost crown structures, were compared.

Joos[11] has stated that variations in shear bond strength values are quite common in dental adhesion studies and that such variations are due to differences among the test teeth. In the present study, the values of shear bond strength achieved were found to be a little on the lower side, possibly, due to the differing quality of dentin and differences in the extra-oral storage time. In the present study, composite resin showed the highest shear bond strength values to dentin as compared to compomer and resin-modified glass-ionomer cement, which might be due to the usage of very superficial dentin for bonding of the composite resin and reducing the etching time to less than that used for permanent teeth. The results of the present study were found to be in close agreement with those of other studies which, also, concluded in line with the present study with composite resins showing the highest shear bond strength in their studies.[12-17] Numerous studies have suggested reducing the etching time for primary dentin due to the high reactivity of the primary dentin to etchants as a way to achieve higher bond strength by the formation of a more homogenous hybrid layer.[18-21] Nör *et al*.,[17,18] also, observed that the hybrid layers formed in the primary dentin were nearly 25 to 30% thicker than that of permanent dentin using identical etching times. This increased thickness of the hybrid layer in primary teeth may contribute to the lower shear bond strength values reported in the literature due to the incomplete penetration of monomers into the demineralized area, resulting in a zone of denuded collagen fibrils at the bottom of the hybrid layer.[21]

According to Bordin-Aykroyd *et al*.,[19] the bond strength of any dental adhesive restorative material depends on the calcium level or the total area of the solid dentin available. As the dentin approaches the pulp, the calcium level decreases that subsequently leads to lower bond strength. Furthermore, in the present study, compomer showed higher shear bond strength values as compared to resin-modified glass-ionomer cement, which was attributed to the usage of two-step etch and rinse (Prime and Bond NT) in the present study rather than the PSA prime/adhesive system. According to Hse *et al*.,[22] the bonding mechanism of self-etching primer is not fully apparent. The PSA prime/adhesive system contains PENTA (dipentaerythritol pentaacrylate) through which the adhesive is claimed to form ionic bonds to the inorganic part of the tooth structure. This adhesive system aims to modify the smear layer to incorporate it in the bonding process but is not acidic enough to form a distinct hybrid layer. Consequently, the smear layer modifying primer is very superficially interrelated to the dentin without any collagen fibrils exposure, whereas the dentinal tubules remain plugged by the smear debris, thus, resulting in reduced bond strength of the compomer to primary dentin using PSA prime/adhesive system. A similar study conducted by Eick *et al*.[23] attributed the lower bond strength achieved with the PSA prime/adhesive system to the fact that dentin was wetted but not penetrated with the PSA prime/adhesive system, resulting in lower values of bond strength observed with the compomer. It has, also, been proposed that etching with phosphoric acid improves the retention and sealing ability of the compomer. This is, also, supported by other authors who found that the self-etching systems afford poor performance compared with the conventional adhesion systems used for resin-type composites and compomer in both primary and permanent teeth.[24-26] However, numerous studies have, also, concluded in favor of the self-etching adhesive systems with them representing a good alternative as they minimize the number of required treatment steps as compared to the traditional systems that involve separate acid etching and adhesive application procedures.[27-29]

## Conclusions

From the observations made in the present in-vitro study, it could be concluded that composite resin showed the highest shear bond strength value (11.7 ± 3.07 MPa), followed by compomer (7.74 ± 4.16 MPa) and resin-modified glass-ionomer cement (4.43 ± 2.08 MPa), thereby, making composite resin the best restorative material available in terms of shear bond strength in the primary dentition. This is more of a clinical advantage as the treatment time is reduced in performing a composite restoration, as well as this helps in attaining good patient cooperation.

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### Conflicts of interest
There are no conflicts of interest.

## References

1. Croll TP, Bar-Zion Y, Segura A, Donly KJ. Clinical performance of resin-modified glass ionomer cement restorations in primary teeth: A retrospective evaluation. J Am Dent Assoc 2001;132:1110-6.
2. Yoonis E, Kukletová M. Tooth-colored dental restorative materials in primary dentition. Scripta Medica Mater Sci 2009;82:108-14.
3. Tran LA, Messer LB. Clinicians' choices of restorative materials for children. Aust Dent J 2003;48:221-32.
4. Kilpatrick NM. Durability of restorations in primary molars. J Dent 1993;21:67-73.
5. Dutta BN, Gauba K, Tewari A, Chawla HS. Silver amalgam versus resin-modified GIC class-II restorations in primary molars:

Twelve month clinical evaluation. J Indian Soc Pedod Prev Dent 2001;19:118-22.
6. Bishara SE, Olsen ME, Damon P, Jakobson JR. Evaluation of a new light-cured orthodontic bonding adhesive. Am J Orthod Dentofacial Orthop 1998;114:80-7.
7. Megid FY, Salama FS. Shear bond strength of Dyract compomer material to dentin of primary molars. J Clin Pediatr Dent 1997;21:305-10.
8. Tay FR, Smales RJ, Ngo H, Wei SH, Pashley DH. Effect of different conditioning protocols on adhesion of a GIC to dentin. J Adhes Dent 2001;3:153-67.
9. Lührs AK, Guhr S, Günay H, Geurtsen W. Shear bond strength of self-adhesive resins compared to resin cements with etch and rinse adhesives to enamel and dentin in-vitro. Clin Oral Investig 2010;14:193-9.
10. Atash R, Van den Abbeele A. Bond strengths of eight contemporary adhesives to enamel and to dentine: An in-vitro study on bovine primary teeth. Int J Paediatr Dent 2005;15:264-73.
11. Joos RW. Status of adhesives of dentin. Northwest Dent 1980;59:224-7.
12. Fagan TR, Crall JJ, Jensen ME, Chalkley Y, Clarkson B. A comparison of two dentin bonding agents in primary and permanent teeth. Pediatr Dent 1986;8:144-6.
13. Hosoya Y, Nishiguchi M, Kashiwabara Y, Horiuchi A, Goto G. Comparison of two dentin adhesives to primary vs. permanent bovine dentin. J Clin Pediatr Dent 1997;22:69-76.
14. Hosoya Y, Tominaga A, Kakazu K, Nishiguchi M, Kashiwabara Y, Goto G. A comparison of three dentin adhesives to permanent dentin in regards to those of primary dentin. Ped Dent J 1996;6:23-32.
15. Mazzeo N, Ott NW, Hondrum SO. Resin bonding to primary teeth using three adhesive systems. Pediatr Dent 1995;17:112-5.
16. Donly KJ, Keprta M, Stratmann RG. An in-vitro comparison of acid etched vs. non-acid etched dentin bonding agents/composite interfaces over primary dentin. Pediatr Dent 1991;13:204-7.
17. Nör JE, Feigal RJ, Dennison JB, Edwards CA. Dentin bonding: SEM comparison of the resin-dentin interface in primary and permanent teeth. J Dent Res 1996;75:1396-403.
18. Nör JE, Feigal RJ, Dennison JB, Edwards CA. Dentin bonding: SEM comparison of the dentin surface in primary and permanent teeth. Pediatr Dent 1997;19:246-52.
19. Bordin-Aykroyd S, Sefton J, Davies EH. In-vitro bond strengths of three current dentin adhesives to primary and permanent teeth. Dent Mater 1992;8:74-8.
20. Shashikiran ND, Gunda S, Subba Reddy VV. Comparison of resin-dentine interface in primary and permanent teeth for three different durations of dentine etching. J Indian Soc Pedod Prev Dent 2002;20:124-31.
21. Sardella TN, de Castro FL, Sanabe ME, Hebling J. Shortening of primary dentin etching time and its implication on bond strength. J Dent 2005;33:355-62.
22. Hse KM, Leung SK, Wei SH. Resin-ionomer restorative materials for children: A review. Aust Dent J 1999;44:1-11.
23. Eick JD, Miller RG, Robinson SJ, Bowles CQ, Gutshall PL, Chappelow CC. Quantitative analysis of the dentin adhesive interface by Auger spectroscopy. J Dent Res 1996;75:1027-33.
24. da Silva Telles PD, Aparecida M, Machado M, Nör JE. SEM study of a self-etching primer adhesive system used for dentin bonding in primary and permanent teeth. Pediatr Dent 2001;23:315-20.
25. Agostini FG, Kaaden C, Powers JM. Bond strength of self-etching primers to enamel and dentin of primary teeth. Pediatr Dent 2001;23:481-6.
26. Pashley DH, Tay FR. Aggressiveness of contemporary self-etching adhesives. Part II: Etching effects on unground enamel. Dent Mater 2001;17:430-44.
27. Hannig M, Reinhardt KJ, Bott B. Self-etching primer vs phosphoric acid: An alternative concept for composite-to-enamel bonding. Oper Dent 1999;24:172-80.
28. Kaaden C, Powers JM, Friedl KH, Schmalz G. Bond strength of self-etching adhesives to dental hard tissues. Clin Oral Investig 2002;6:155-60.
29. Perdigão J, Swift EJ Jr, Gomes G, Lopes GC. Bond strengths of new simplified dentin-enamel adhesives. Am J Dent 1999;12:286-90.