

# Comparative Evaluation of Microleakage of Zirconomer, Amalgomer CR, and Conventional Glass Ionomer (Type II) as Restorative Cements in Primary Teeth: An *in vitro* Study

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## ABSTRACT

**Aim:** The aim of this *in vitro* study was to evaluate and compare the microleakage of three different restorative cements, namely zirconomer, amalgomer CR, and conventional glass ionomer cement (GIC, type II).

**Materials and methods:** The present *in vitro* study was carried out in the Department of Pedodontics and Preventive Dentistry, Hitkarini Dental College & Hospital, Jabalpur (Madhya Pradesh, India) in collaboration with the Department of Biotechnology, Nanaji Deshmukh University of Veterinary Science, Jabalpur, Madhya Pradesh, India, and Excellent Bio Research Solutions Private Limited (Daksh Laboratories), Jabalpur, Madhya Pradesh. A total of 45 human noncarious primary molars were selected. The selected teeth were extracted for the reason of overretention or orthodontic purpose. Total samples were divided into three groups: 15 samples in each group—group I: zirconomer (Shofu Inc., Kyoto, Japan), group II: amalgomer CR (Advance Health Care, Ltd., Tonbridge, UK), and group III: conventional GIC (Medicept Type II, Ltd., India). Hand scalers were used to remove calculus if present on the root surface and the teeth were stored in glass container containing normal saline. In all the samples class I cavity was prepared on the occlusal surfaces of the extracted noncarious primary molars using high-speed hand piece. From the previously divided three groups, i.e., groups I, II, and III, each group contains 15 teeth. All teeth were restored with either of the three restorative materials. Restored samples from the three groups were then subjected to thermocycling. The teeth were immersed in an aqueous solution of methylene blue for 48 hours and then sectioned longitudinally in a buccolingual direction through the center of both cavities using a low-speed diamond saw. The dye penetration depth along the occlusal margin was evaluated for each group. Dye penetration scores were analyzed by two calibrated and blinded evaluators. The mean value of the two was evaluated and recorded for statistical analysis.

The scoring for microleakage assessment was done as described by Prabhakar et al.

## Scoring criteria:

- 0 = No dye penetration
- 1 = Dye penetration between the restoration and the tooth into enamel and dentin
- 2 = Dye penetration between the restoration and the tooth in the enamel and dentin
- 3 = Dye penetration between the restoration and the tooth into pulp chamber

**Results:** The data were analyzed with nonparametric test (Kruskal–Wallis test;  $p < 0.005$ ). There was no significant difference between the three restorative cements. The results showed that conventional GIC exhibited (type II) least microleakage than that of zirconomer, amalgomer CR, and maximum with zirconomer. Amalgomer CR exhibited more microleakage than conventional GIC.

**Conclusion:** Within the limitations of this study, none of the material was free from microleakage. Although the new materials have certain advantage of strength, they lack microleakage.

**Keywords:** Amalgomer CR, Conventional glass ionomer, Microleakage, Zirconomer.

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## INTRODUCTION

Over the past 50 years, many changes have occurred in restorative materials in development and on availability.<sup>1</sup> Restorative dentistry, in its infancy, was dominated by the simple principle of “Extension for Prevention,” laid down by GV Black and which was partially dictated by the restorative material available at that time.<sup>2</sup> Restoration in primary teeth differs from the permanent teeth because of limited lifespan of teeth, different morphology of primary molar teeth, and their susceptibility to caries, lower biting force in children.<sup>3</sup> The ideal requisites for restorative material are that it should have a good color stability, have a coefficient of thermal expansion, have biocompatibility similar to that of natural tooth structure, excellent marginal seal, and the ability to adhere chemically to enamel and dentin.<sup>4</sup>

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Glass ionomer cement (GIC) seems to meet most of these requirements along with particular advantage. But, there were certain drawbacks in conventional GIC for use in primary molar due to its low physical properties and poor long-term performance. These findings contradict the choice of materials made by clinicians worldwide.<sup>5</sup> To overcome the above-mentioned drawback, a high-strength restorative material which has been reinforced with ceramic and zirconia filler known as zirconomer (white amalgam) has been introduced in dentistry.<sup>6</sup> The most recent ceramic-reinforced glass ionomer, amalgomer CR (Advanced Health Care Ltd., Kent, England), is used in children. It has been proven that amalgomer CR exhibited higher shear bond strength than that of miracle mix.<sup>3</sup>

Microleakage is identified as one of the significant problems because of interfacial gap formation, which can result in recurrent caries, possible pulp involvement, tooth discoloration, and restoration replacement.<sup>7</sup> Controlling microleakage has always been an important goal of operative dentistry.<sup>6</sup>

The clinical success of this new restorative material depends on a good adhesion with the dentinal surface, which should resist various dislodging forces acting on them; hence, the present study was undertaken to evaluate the microleakage of three restorative cements.<sup>8</sup> Due to lack of studies on recent modified GICs on primary teeth, the present *in vitro* study was conducted to compare the coronary microleakage of following restorative cements: Conventional GICs, zirconomer, and amalgomer CR.

## MATERIALS AND METHODS

The present *in vitro* study was carried out in the Department of Pedodontics and Preventive Dentistry, Hitkarini Dental College & Hospital, Jabalpur, Madhya Pradesh, India. The aim of this *in vitro* study was to evaluate and compare the microleakage of three different restorative cements, namely zirconomer, amalgomer CR, and conventional GIC (type II).

Ethical approval was obtained from the Ethical Committee of Hitkarini Dental College & Hospital, Jabalpur, India. A total of 45 human noncarious primary molars were selected. The selected teeth were extracted for the reason of overretention or orthodontic purposes.

The total samples were divided into three groups:

1. Group I (n = 15): Zirconomer (Shofu Inc., Kyoto, Japan)
2. Group II (n = 15): Amalgomer CR (Advance Health Care, Ltd., Tonbridge, UK)
3. Group III (n = 15): Conventional GIC (Fuji Type II, Ltd., India)

### Inclusion Criteria

- Noncarious primary molars with roots

### Exclusion Criteria

- Grossly decayed tooth
- Teeth with facets
- Fractured teeth
- Teeth with aberrant anatomy
- Teeth with previous restoration

### Procedure

All the samples were cleaned with soap and washed in running water. Hand scalers were used to remove calculus if present on the root surface and the teeth were stored in glass container containing normal saline. After surface debridement, they were examined for defects in enamel and dentin using magnifying glass.

In all the samples, class I cavity was prepared on the occlusal surface of the extracted noncarious primary molars using high-speed hand piece with round diamond bur (No. 012) and cylindrical diamond burs (No. 010) by a single operator in an ideal condition. The bur was replaced after every four preparations. Preparation of the cavities was standardized with respective sample using template of 3 mm diameter and 2 mm depth. The cavities were rinsed with water and dried with an air spray. All teeth were restored with either of the three restorative materials and then left for 3 minutes. At 7 minutes after placement, the material was hard enough to finish using Fine Grit Finishing Diamond Burs, followed by the use of petroleum jelly as lubricant to prevent excess heat. After finishing, the surface should be coated with varnish for protection from moisture in each of the samples.

### Thermocycling

All the restored teeth were stored in distilled water at 37°C for 24 hours to prevent dehydration of tooth. All the restored teeth from the three groups were then subjected to thermocycling at 5°C and 55°C for 1,000 cycles with a dwell time of 30 seconds at each temperature, and 10 seconds was the transferring time between the two temperature baths.

### Microleakage Assessment

After thermocycling, all the apices of the roots were sealed with modeling wax and the specimens were coated with two layers of nail polish, leaving 1 mm window around the cavity margins. The teeth were immersed in an aqueous solution of methylene blue for 48 hours at room temperature, then removed from the dye, rinsed in tap water for 30 seconds, and dried using air water syringe. Subsequently, the teeth were embedded in polyvinylchloride pipe using cold cure acrylic (Pyrax Roorkee, Uttarakhand, India) and sectioned longitudinally in a

buccolingual direction through the center of both cavities using a low-speed diamond saw.

The dye penetration depth along the occlusal margin was evaluated for each group. Dye penetration scores were analyzed by two calibrated and blinded evaluators. The mean value of the two was evaluated and recorded for statistical analysis.

The scoring for microleakage assessment was done as described by Prabhakar et al.<sup>9</sup>

### Scoring Criteria

- 0 = No dye penetration.
- 1 = Dye penetration between the restoration and the tooth into enamel only.
- 2 = Dye penetration between the restoration and the tooth in the enamel and dentin.
- 3 = Dye penetration between the restoration and the tooth into pulp chamber.

### RESULTS

The results were tabulated and statistically analyzed by using Kruskal–Wallis analysis of variance for multiple group comparison followed by Mann–Whitney U-test for pairwise comparison. The result shows that microleakage score is highest for group I (zirconomer) than for group II (amalgomer CR) and then least for group III (Fuji II) (group I > group II > group III) (Table 1).

Mean rank of groups I and II showed 25.13 and 25.07 respectively, least showed by group III, i.e., 18.08. Degree of freedom (df) for microleakage using Kruskal–Wallis test was  $\chi^2 = 3.054$ ,  $df = 2$ . There was no significant difference between the groups for microleakage. All three materials were same with respect to microleakage (Table 2).

Mann–Whitney's U-test was applied to compare the significance in microleakage scores between any of the two groups studied. There was no significant difference between pairwise comparisons of three groups (Table 3).

**Table 1:** Mean, standard deviation (SD), median, minimum, and maximum values of microleakage in different experimental groups

Experimental groups	n	Microleakage scores		
		Mean $\pm$ SD	Median	Min–Max
Group I	15	1.53 $\pm$ 0.64	1.00	1.00–3.00
Group II	15	1.47 $\pm$ 0.64	2.00	0.00–2.00
Group III	15	1.20 $\pm$ 0.41	1.00	1.00–2.00

**Table 2:** Comparison of microleakage in different experimental groups using Kruskal–Wallis test

Experimental groups	Mean rank	Kruskal–Wallis test	p-value
Group I	25.13	$\chi^2 = 3.054$ , $df = 2$	0.217 (>0.05)
Group II	25.07		Not significant
Group III	18.80		

**Table 3:** Pairwise comparison of microleakage in different experimental groups using Mann–Whitney U-test

Comparison groups	Mean rank	Mann–Whitney U-test	p-value
Groups I and II	15.53 15.47	MW = 112.000	1.000 (>0.05)
Groups I and III	17.60 13.40	MW = 81.000	0.202 (>0.05)
Groups I and III	17.60 13.40	MW = 81.000	0.202 (>0.05)
Not significant			

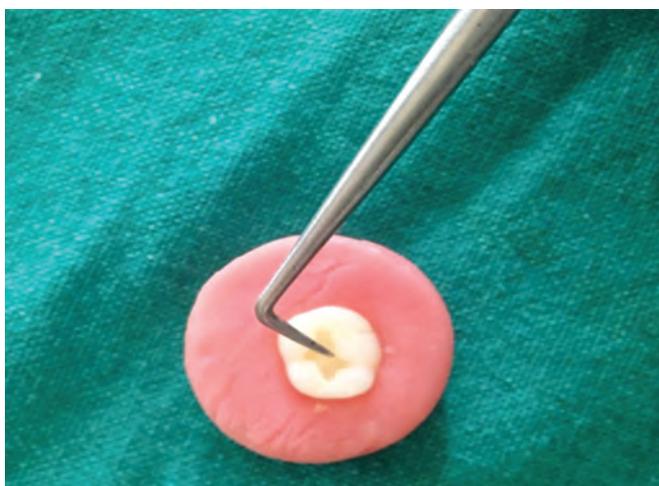
### DISCUSSION

Restorative dentistry in children is one of the most challenging branches in dentistry as children have variable levels of cooperation, lesser attention span, and require stringent safety measures.<sup>3,10</sup> It is important to have good marginal seal and better bond strength for the longevity of restorative material, thereby reducing the marginal leakage which is the precursor of tooth discoloration, staining of restoration, secondary caries, marginal deterioration, postoperative sensitivity, and pulpal pathology.<sup>4,5,7,8,11,12</sup>

Microleakage is defined as the clinically detectable passage of bacteria, molecules, fluids, or ions between a cavity wall and the restorative materials applied to it, and is a major challenge in clinical dentistry.<sup>13–15</sup> This may occur because of changes in dimensional temperature and mechanical stress or lack of adaptation of the restorative material, resulting in a gap at the tooth material junction.<sup>16,17</sup>

There are various methods to detect the microleakage, which include chemical tracers, the use of dyes, radioactive tracers, scanning electron microscopy, electrochemical method neutron activation analysis, air pressure, and fluid filtration.<sup>4</sup> The most common methods were those with stained solutions like aniline blue, eosin, erythrosine, fluorescein, methylene blue, and Indian ink.<sup>4,11</sup> Out of the various studies, methylene blue has been proved to be a useful aid in endodontics. In the present study also, methylene blue (0.5%) was used. Methylene blue is a superior tracer of microspaces. This view is supported by Matloff et al, who found methylene blue to be a more sensitive indicator of leakage than the three radioisotopes tested.<sup>18,19</sup>

In the present study, human extracted primary teeth were selected. Reason for the selection of primary teeth is that restoration differs from permanent teeth due to the limited lifespan of teeth, different morphology of primary molars, lower biting forces in children, and their susceptibility to caries. Pashley<sup>20</sup> reported that blood or salivary contamination promotes physical obstacles by deposition of macromolecules of these contaminants into the dentinal tubules. Bendeli et al stated that saliva contamination might be a risk factor to the bonding process. Also, the permanent teeth contain more inorganic content as compared



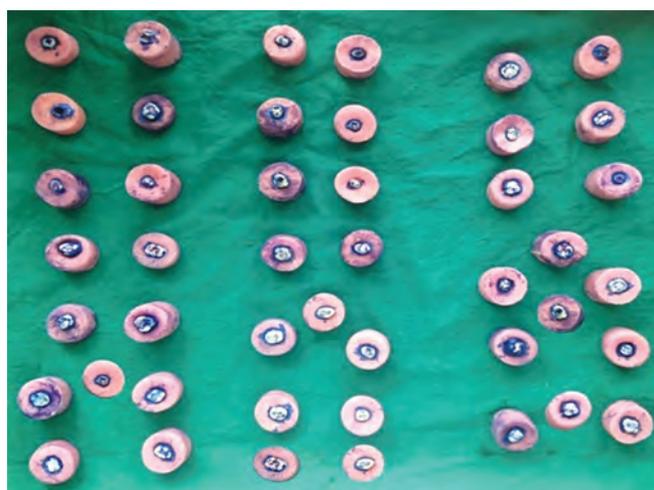
**Fig. 1:** Measurement (width and depth) of class I cavity using periodontal probe



**Fig. 2:** Sample restored with amalgomer CR, zirconomer, and conventional glass ionomer



**Fig. 3:** Two layers of nail paint 1 mm around restoration



**Fig. 4:** Samples after dye immersion

with the primary teeth, leading to the strong bond, which in turn might have led to the decrease in microleakage.<sup>21</sup> According to Hirayama who revealed that peritubular dentin of primary teeth is two to five times thicker than that of permanent teeth, with thicker peritubular dentin, there is relatively less intertubular dentin. And since intertubular dentin is the major area where bond occurs, primary teeth provide lesser bonding as compared with the permanent teeth leading to increase in microleakage.<sup>22</sup>

In the present study, class I cavities were prepared because of its "c" factor, i.e., ratio between number of bonded and unbonded surface as suggested by Roberson et al and Santini et al.<sup>23,24</sup> A possible explanation for the lower microleakage scores may be the three-dimensional structure,<sup>16,25</sup> hence, resulting in a better sealed restoration and reducing stress buildup opposing wall, limits the development of contraction forces between and gap formation.<sup>26</sup>

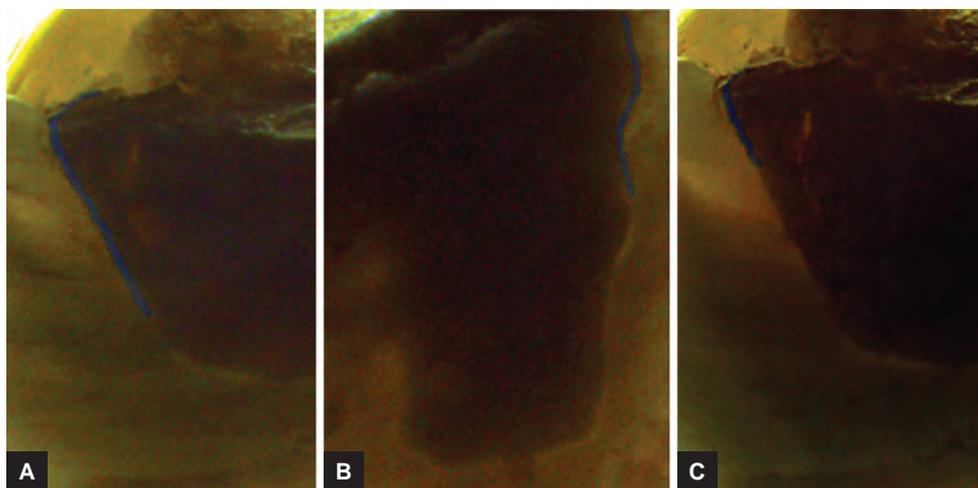
Powis et al<sup>27</sup> suggested acrylic acid as the most effective conditioner because acrylic acid has little effect on dental tissues and removes the smear layer and surface



**Fig. 5:** Samples after buccolingual sectioning

contamination without opening the dentinal tubules more than needed.

The current study examined the microleakage of different types of glass ionomer restorations placed in class



**Figs 6A to C:** Microscopic view of dye penetration

I cavities in primary teeth and subjected to thermocycling due to mimic intraoral temperature variations compatible with oral cavity.<sup>6,14,28</sup> The number of cycles used in this study (1,000 cycles) is in accordance with the number of cycles mentioned in previous studies.<sup>8,11,29</sup>

Glass ionomer cements are adhesive bioactive restorative materials with therapeutic action that were developed during the late 1960s.<sup>1</sup> The anticariogenic property resulting from fluoride release turned out to be the most attractive aspect of this dental material.<sup>30</sup> However, conventional GICs have been plagued by several negative characteristics, such as prolonged setting time that restricts finishing and polishing for approximately 24 hours, sensitivity to moisture during initial hardening, strength, dehydration, rough surface texture, opaqueness, low fracture toughness, and poor wear resistance.<sup>29,31</sup> In the present study, Fuji Type II (1.20) showed least microleakage than zirconomer (1.53) and amalgomer CR. A similar study conducted by Shruthi et al<sup>4</sup> compared among Fuji II, vitremer, and compoglass F and they concluded from the study that Fuji II showed least microleakage than vitremer and compoglass F.

In this study, zirconomer exhibited the highest microleakage as compared with amalgomer CR and Fuji II GC, but amalgomer CR has more microleakage compared with Fuji II. Zirconomer (Shofu Inc., Kyoto, Japan), a new class of glass ionomer restorative material, exhibits strength and durability of amalgam, along with bondable and fluoride releasing property of GIC; at the same time, it eliminates the hazardous property of amalgam because of mercury. Addition of zirconia as filler particle in the glass component of zirconomer improves mechanical properties of the restoration by reinforcing structural integrity of the restoration in load-bearing areas where amalgam is the material of choice. Combination of outstanding strength, durability, and sustained fluoride protection deems with chemical bonding.<sup>32</sup> Shameera et al conducted a compara-

tive study of microleakage among GC Fuji IX, Amalgam, and Zirconomer. There is research supporting the present study result that GC Fuji IX Extra was much better than Zirconomer.<sup>33</sup> Patel et al<sup>6</sup> conducted a study and results were similar to the present study. They showed that zirconomer exhibited the highest microleakage as compared with composite and amalgam, but composite has higher microleakage as compared with amalgam and lower microleakage as compared with zirconomer.

No studies were found till date on amalgomer CR in relation to microleakage. Its shear bond strength has been evaluated by Murthy and Murthy<sup>3</sup> among Miracle Mix, Ketac Molar, and amalgomer CR, and result showed amalgomer CR exhibited statistically significant higher shear bond strength of 6.38 MPa to primary teeth and has better adhesion to the primary teeth compared with other materials.

## LIMITATIONS

Several authors have reported microleakage of restorative materials *in vivo*, but variation in study designs and different thermal factors make comparisons with these studies somewhat difficult.<sup>34</sup> Even though care was taken to replicate the conditions that exist in the oral cavity as far as possible, constant washing action of saliva, sudden changes in temperature and in pH could not be duplicated. Quantity and quality of saliva, plaque, physical and chemical properties of food and liquids, masticatory functions, and oral health conditions may also influence the results. Another factor that influences the marginal integrity under clinical conditions is the functional stress by mastication.<sup>34</sup> These factors may affect microleakage of restorative cements in primary teeth also.

## CONCLUSION

Within the limitations of this study, none of the material was free from microleakage. Although the new materials

have certain advantage of strength, they lack microleakage. Despite the newer material, zirconomer had the highest microleakage compared with amalgomer CR and conventional glass ionomer type II.

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