Comparative evaluation of microleakage of three restorative glass ionomer cements: An *in vitro* study

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Abstract

Purpose: The aim of this study was to compare the microleakage of glass ionomers (conventional and resin modified) with that of recently introduced nanoionomers. **Materials and Methods:** Standardized class I and class V cavities were prepared on 120 young permanent teeth. Samples were equally divided into group I (class I restorations) and group II (class V restorations), and further divided into subgroups. The subgroups were restored with Fuji IX, Fuji II LC, and newly introduced Ketac™ N 100 (KN 100). Samples were thermocycled and submerged in Acridine dye for 24 h. Samples were sectioned to view under fluorescent microscope and marginal leakage was evaluated by Chi-square and Kruskal — Wallis test. **Results:** Fuji IX showed the maximum leakage, followed by LC II and the least was observed in KN 100. In class I restorations, there was significant difference while comparing Fuji IX with Fuji LC II and KN 100 and nonsignificant difference between LC II and KN100. In class V restorations, Fuji IX and KN100, KN 100 and LC II showed significant difference. Fuji IX and LC II showed nonsignificant difference. **Conclusion:** Within the limitations of this study, Fuji IX showed the maximum microleakage. KN 100 showed minimum leakage, better sealing ability, and was more consistent.

Key words: Fluorescent microscope, microleakage, nanoionomer

INTRODUCTION

A good seal at tooth surface — restoration interface is very essential for an ideal restorative material to minimize the microleakage. Poor adaptation can lead to marginal discoloration, post-operative sensitivity, bacterial penetration, secondary caries, failure of restoration, and pulpal inflammation. Recent advancement in technology and devices has sought to improve the quality and longevity of restorative material to provide predictable life of the treatment. Glass ionomers seem to be the material of choice in class I and class V cavities in primary teeth.[1-6] At the same time, there is evidence to support that conventional glass ionomer cement is inappropriate for use in primary molars due to its low physical properties and poor long-term performance.[7-9] These findings contradict the choice of materials made by clinicians worldwide.

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Similarly, there is substantial evidence to support the use of glass ionomers for class V restorations in young permanent teeth in high-risk patients and also as interim therapeutic restoration (ITR).[10]

A new generation of resin-modified glass ionomer cement was introduced in 2007. Ketac Nano (3M ESPE), described by the manufacturers as a "nanoionomer," is known to exhibit improved esthetics while retaining the beneficial qualities like fluoride release.[11] Incorporation of nanotechnology enhances the physical properties like wear resistance, polishability, and esthetics.[12] Basic properties like low microleakage and high bond strength are critical for success of any restorative material. This *in vitro* study was carried out to evaluate and compare microleakage properties of two most commonly used glass ionomers worldwide (conventional glass ionomers — Fuji IX and resin-reinforced glass ionomers — Fuji II LC) with the recently introduced nanoionomer (Ketac™ N 100 or KN 100).

MATERIALS AND METHODS

A total of 120 noncarious, nonfluorosed human young maxillary permanent teeth with sound occlusal surface, extracted for orthodontic purpose, were taken for the study to determine microleakage in class I and class V restoration. The study received the necessary ethical clearance from IRB committee of Darshan Dental College, Udaipur, India.

All specimens were thoroughly cleaned and stored in normal saline. The teeth were randomly divided into two groups. Sixty specimens (group 1) were evaluated for class I restorations and 60 specimens for class V restorations (group 2). Small class I and class V cavities were prepared on the extracted young permanent human maxillary first premolar teeth by a single operator in ideal conditions. Class V cavity was prepared on the buccal surface, and the lingual surface of teeth was kept intact. This was followed by fabrication of wax pattern in both types of preparations and was casted to prepare molds for standardization of rest of the samples.

Group 1 (class I restorations) was further randomly divided into three subgroups (A_1, B_1, and C_1) of 20 teeth each. A1 was restored with Fuji IX, B1 with Fuji II LC, and C1 with KN 100. Group 2 (class V restorations) was similarly divided into three subgroups (A_2, B_2, and C_2).

For groups A_1 and A_2 restoration was done with Fuji IX for class I preparation and class V preparation, respectively. Cement was mixed according to manufacturer's instruction. For groups B_1 and B_2 Fuji LC II was used for class I and class V restorations. Cavity conditioner was applied for 10 sec. Cement was mixed according to manufacturer's instruction and teeth were restored. Restorations were light cured for 20 sec. The output of light was maintained constantly throughout the study.

For groups C_1 and C_2, KN 100 was used for class I and class V restorations. After cavity preparation, teeth were dried and primer was applied for 15 sec. Surface was dried with air syringe for 10 sec. Primed surface was light cured for 10 sec using light cure unit. To mix the material, cap form the clicker was removed and material was dispensed on a mixing pad by depressing the clicker level fully. Both the pastes were mixed with plastic spatula until a uniform color was achieved. Cavities were filled with KN 100 ionomer.

All the restored teeth were stored in normal saline at 37°C for 2 days.

THERMOCYCLING AND DYE IMMERSION

All the specimens were subjected to thermocycling. This was done for 250 times between baths of 5°C, 37°C, and 55°C, with a dwell time of 30 sec in each bath.

External surface of all samples was coated with two coats of varnish to seal the radicular part of samples, except 1 mm of periphery of the restorations. The apices of roots were sealed with glass ionomer cement.

One percent aqueous solution of Acridine dye was prepared with water and all 60 samples were submerged in the solution for 24 h. Then, the samples were washed under tap water to remove the excess dye. Then specimens were embedded in acrylic blocks up to cemento-enamel junction and then they were subjected to sectioning for the assessment of dye penetration.

ASSESSMENT OF DYE PENETRATION

The samples were sectioned in longitudinal direction using thick, slow-speed diamond-coated disk under water coolant. A first section was centered along the mesiodistal axis to separate the buccal and lingual surfaces. One-millimeter-thick buccolingual sections were made for each specimen, which was standardized using a metal gauge. To maintain even plane for each section, carborundum stone was used. The degree of marginal leakage was evaluated under fluorescent microscope with magnification of 4×. The degree of microleakage was measured by a single observer using the scoring criteria described by Khera and Chan (1978).[13] To rule out the intra-examiner variability, replicate readings were taken randomly with a k-value of 0.90.

The scoring criteria used for microleakage were as follows:

- 0º = no leakage
- 1º = less than or up to one-half of the depth of the cavity preparation
- 2º = more than one-half of the cavity preparation involved, but not up to the junction of the axial and occlusal or cervical wall

3° = dye penetration up to the junction of the axial and occlusal or cervical wall, but not including the axial wall

4° = dye penetration including the axial wall

The data were collected, tabulated, and statistically analyzed using SPSS 10 (SPSS Inc., Chicago, IL, USA) statistical analysis package software.

RESULTS

None of the materials was free of microleakage. The microleakage scores with percentage are given in Tables 1 and 2. Chi-square test confirmed maximum leakage with Fuji IX compared to other materials in class I and V restorations [Tables 1 and 2]. Fuji LC II showed moderate leakage and was less consistent. KN 100 showed the least leakage and was more consistent compared to the other two materials. Further, matched analysis by Kruskal — Wallis test confirmed significant difference between Fuji IX and Fuji LC II and between Fuji IX and KN 100 in class I restoration. There was no significant difference between Fuji LC II and KN 100 in class I restoration, whereas in class V restorations, there was significant difference between Fuji LC II and KN 100. Also, there was a significant difference between Fuji IX and Fuji LC II and between Fuji IX and KN 100 in cervical restorations [Tables 3-5]. Overall, KN 100 performed better than the other restorative materials and was more consistent. Fuji LC II showed moderate leakage and Fuji IX showed the maximum leakage.

Table 1: Frequency distribution of microleakage between various groups in class I restorations

Score	0°	1°	2°	3°	4°	Total
Fuji IX	30%	10%	10%	20%	30%	70%
Fuji II LC	60%	20%	0	10%	10%	40%
Ketac N 100	50%	30%	10%	10%	0	50%

Chi-square test value = 6.67 (*P* value = 0.53), not significant

Table 2: Frequency distribution of microleakage between various groups in class V restorations

Score	0°	1°	2°	3°	4°	Total
Fuji IX	20%	10%	20%	20%	30%	80%
Fuji II LC	40%	20%	10%	20%	10%	60%
Ketac N 100	50%	30%	0%	10%	10%	50%

Chi-square test value = 6.77 (*P* value = 0.01), hence nonsignificant

Table 3: Kruskal — Wallis test for intergroup comparison

	Mean rank in class I restorations	*P* value	Mean rank in class V restorations	*P* value
Fuji IX	16.9	0.04, significant	19.1	0.41, nonsignificant
Fuji LC II	24.1		21.9	

Table 4: Kruskal — Wallis test for intergroup comparison

	Mean rank in class I restorations	*P* value	Mean rank in class V restorations	*P* value
Fuji IX	15.9	0.008, significant	15.2	0.003, significant
Ketac N 100	25.1		25.8	

Table 5: Kruskal — Wallis test for intergroup comparison

	Mean rank in class I restorations	*P* value	Mean rank in class V restorations	*P* value
Fuji LC II	23.7	0.07, nonsignificant	16.5	0.02, significant
Ketac N 100	17.3		24.5	

DISCUSSION

In the present study, all the samples were thermocycled in cold and hot bath within the range of 5°C, 37°C, and 55°C, with a dwell time of 30 sec to simulate the oral environment. The same has been recommended earlier.[14]

However, thermocycling regimen provides thermal stresses by variation in temperature. Material reaches thermal equilibrium only on resting bath. This variation is likely to stress the material and increase leakage.[15]

Different methods have been used including silver nitrate, air pressure, radioactive isotopes, and Scanning electron microscope (SEM) to evaluate the microleakage of restoration.[16,17] Dye penetration has been considered as an easy method since the dye penetrates successfully into the flaws and crevices of the test object.[18] Microleakage was assessed by using fluorescent dye under fluorescent microscope, as described by Nayak *et al.* (2002),[19] where sections with microleakage showed apple green color of the fluorescent dye between the restoration and tooth. The same was also observed in a previous study done by Klara *et al.* (1983).[20]

In the present study, Fuji IX showed more microleakage [Tables 1 and 2] and was less consistent. Mali *et al.*[21] found similar result with more microleakage with conventional glass ionomer as compared to resin glass ionomer and composite. Tensile bond strength of compoglass is significantly greater than Fuji IX GP and Fuji II LC,[22] and has chemical bonding with tooth structure. Dehydration of Fuji IX is controlled by the presence of tubular fluid in dentin. Continuous outward flow of fluids form freshly cut dentin increases the wetting of dentin and improves hydrated gel phase during solidification and allows self-repairing process.[23]

Hence, glass ionomer maintains its bulk volume through internal microcracks. With water sorption, the cracks close to repair cohesive strength, and the dimensional stability of glass ionomer cement is maintained, resulting in excellent adaptation with tooth structure. In *in vitro* condition, absence of water and lower cohesive strength can alter the properties of glass ionomer cement, which may have resulted in leakage in the present study.

Fuji LC II showed variable results and moderate leakage with cavity margins. Use of cavity conditioner with poly acrylic acid and aluminum chloride could have provided better seal. It allows transformation of smooth enamel into irregular etched surface for the resin matrix to penetrate and have interlocked with the enamel, leading to good adhesion.

However, leakage of Fuji II LC in the present study could be due to rigid framework and less capability of elastic deformation at the initial stage of polymerization. Brackett *et al.* (1995)[23] found adequate sealing ability with resin-modified glass ionomer cement. They believed microleakage could be minimized by avoiding dehydration. Similar results have been found in another study where two resin-modified glass ionomers (Fuji II LC and Vitremer) showed satisfactory sealing ability at tooth margins, when compared with compomer.[24] Croll *et al.* (2001)[25] carried out clinical trial of resin-modified glass ionomer in primary teeth and recommended it for pediatric patients due to excellent marginal adaptation. Wilder *et al.*[26] also observed significantly less microleakage with resin-modified glass ionomer compared to conventional glass ionomer cement. In the present study, specimens were stored in saline, which may have resulted in hygroscopic expansion compensating for polymerization shrinkage, as described in previous studies,[15,27] resulting in lesser leakage.

On the other hand, Gerdolle[28] found more leakage with light-cured Glass ionomer cement (GIC) and believed that hygroscopic expansion of the material may have weakened the bond of the material with the tooth, leading to leakage. Different experimental conditions may contribute to the results of the study.

Newly introduce nanoionomer showed minimum microleakage and was more consistent than the other materials, with significantly good adaptation with tooth structure. It performed better than the other two materials while restoring class V cavities. Wadenya *et al.*[29] recommended the use of nanoionomer cements in atraumatic restorative technique and routine dental procedures, respectively. One of the recent studies also found least leakage with nanofilled resin-modified glass ionomer.[30] It has been termed as "tissue-specific direct tooth repair" and recommended for all types of restorations in the primary tooth.[13] In nanoionomer, smaller particle size may have provided more surface area and better flow of the material, resulting in better adaptation with tooth interface. Incremental layer technique for placement of KN 100s may have resulted in better adaptation leading to reduced microleakage.

CONCLUSION

The following conclusions can be drawn from the results of the present study:

1. None of the three materials was free of microleakage. Cavities filled with KN 100, a new resin-modified glass ionomer based on nanotechnology, and Fuji II LC performed similarly, but nanoionomer was more consistent and showed lesser microleakage with better adaptation than Fuji LC II.
2. Fuji IX showed more microleakage as compared to KN 100 and Fuji II LC, which was also statistically significant.

Even though KN 100 showed promising results, the clinical performance of any material cannot be predicted solely on the basis of *in vitro* study. Controlled clinical studies are necessary to draw a definite conclusion of microleakage of KN 100 restorative material.

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