The Saudi Dental Journal (2012) 24, 35–42

King Saud University
The Saudi Dental Journal
www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

An evaluation of microleakage of various glass ionomer based restorative materials in deciduous and permanent teeth: An in vitro study

Teena Singla [a,*], I.K. Pandit [b], Nikhil Srivastava [c], Neeraj Gugnani [b], Monika Gupta [b]

[a] *Department of Pedodontics and Preventive Dentistry, SGRD Dental College, Amritsar, India*
[b] *Department of Pedodontics and Preventive Dentistry, DAV Dental College, Yamunanagar, India*
[c] *Department of Pedodontics and Preventive Dentistry, Subharati Dental College, Meerut, India*

Received 26 March 2011; revised 19 August 2011; accepted 22 October 2011
Available online 16 November 2011

KEYWORDS

Glass ionomer based restorative materials;
Microleakage;
Stereomicroscope

Abstract *Aim:* To evaluate the microleakage of recently available glass ionomer based restorative materials (GC Fuji IX GP, GC Fuji VII, and Dyract) and compare their microleakage with the previously existing glass ionomer restorative materials (GC Fuji II LC) in primary and permanent teeth.
Method: One hundred and fifty (75 + 75) non-carious deciduous and permanent teeth were restored with glass ionomer based restorative materials after making class I cavities. Samples were subjected to thermocycling after storing in distilled water for 24 h. Two coats of nail polish were applied 1 mm short of restorative margins and samples sectioned buccolingually after storing in methylene blue dye for 24 h. Microleakage was assessed using stereomicroscope.
Result: Significant differences ($P < 0.05$) were found when inter group comparisons were done. Except when GC Fuji VII (Group III) was compared with GC Fuji II LC (Group II) and Dyract

* Corresponding author. Address: 18 S.F., HIG Flats, A Block, Ranjit Avenue, Amritsar 143001, Punjab, India. Mobile: +91 09876726150/09779595309.
E-mail address: teenasingla@gmail.com (T. Singla).

Peer review under responsibility of King Saud University.
doi:10.1016/j.sdentj.2011.10.002

Production and hosting by Elsevier

(Group IV), non-significant differences ($P > 0.05$) were observed. It was found that there was no statistically significant difference when the means of microleakage of primary teeth were compared with those of permanent teeth.

Conclusions: GC Fuji IX GP showed maximum microleakage and GC Fuji VII showed least microleakage.

1. Introduction

Restorative dentistry, in its infancy was dominated by the simple principle of ''extension for prevention'' laid down by G.V. Black and which was partially dictated by the restorative materials available at that time. The only materials available at that time were amalgam and gold. These materials were unaesthetic and were incapable of forming any chemical bond with the tooth structure.

The boom in the aesthetic dentistry came with the advent of dentin adhesives.

Realising the advantage of fluoride release in the silicate cements, Wilson and Kent in 1972 developed glass ionomer cements (Sikri, 2002). The advantages of the glass ionomer cements lie in their continuous fluoride release and in their ability to adhere to mineralised tooth structure. But these cements are brittle and their flexural and compressive strengths are much weaker than those of amalgam. To improve the physical properties of the material, metal particle reinforced GIC or cermet cements were developed. They have the advantage of greater flexural strength, less occlusal wear, improved radioopacity and faster setting reaction (Hirschfeld et al., 1992).

Conventional glass ionomer cement was again modified and resin glass ionomer cement which sets by the spectrum of visible light came into existence. These materials have the advantages of longer working time, less sensitivity to water during setting and were more convenient to use (Dutta et al., 2001).

Compomers are the single component materials that combine the advantages of both composites and glass ionomer restorative materials having capabilities of fluoride release, adhesion to tooth structure, biocompatibility and being cured with visible light (Puckett et al., 1995).

The new generation of glass ionomer, GC Fuji IX GP, has been developed which may offer some benefits to the dental patients, especially children. It contains fluoride, adheres to tooth structure without the need of any additional bonding system, has adequate strength and can be finished and polished in one visit.

GC Fuji VII, another new generation of glass ionomer cement, has the advantage of very high fluoride release, it is easy to apply due to the low viscosity, and can be used when saliva control is not possible (GC, 2004–2005).

Material science has advanced by discovering different types of restorative materials and modifications of previously existing ones. Yet the longevity of restoration is essential because of good marginal seal, thereby reducing the marginal leakage which is the precursor of secondary caries, marginal deterioration, postoperative sensitivity and pulpal pathology (Prabhakar et al., 2003). Investigation of micro leakage at the margins would contribute to better assessment of material.

Hence, the present in vitro study was undertaken to evaluate the micro leakage of recently available glass ionomer cements and compare it with that of previously existing glass ionomer based restorative materials in deciduous and permanent teeth.

2. Materials and methods

This study was conducted in the Department of Pedodontics and Preventive Dentistry, Dayanand Anglo Vedic (Centenary) Dental College & Hospital, Yamuna Nagar in association with

Table 1 Various Glass ionomer based restorative materials used in the study.

Material	Composition	
GC FUJI IX GP	Powder	Liquid
	– Fluro alumino silicate glass	– Polyacrylic acid
	– Polyacrylic acid powder	– Polybasic carboxylic acid
GC FUJI II LC	Fluro alumino silicate glass	Polyacrylic acid 20–30%
		2-HEMA 30–35%
		Distilled water 20–30%
		Initiator
		Urethane dimethylacrylate < 10
		Camphorquinone < 1
FUJI GC VII	– Fluro alumino silicate glass	– Polyacrylic acid
	– Polyacrylic acid powder	– Polybasic carboxylic acid
DYRACT	UDMA resin	Prime and Bond NT
	TCB resin	Di-trimethacrylate
	Strontium fluoro silicate glass	Functionalised amorphous silica
	Strontium fluoride	PENTA(dipentaerythritol penta acrylate monophosphates)
	Photoinitiator	Photoinitiators
	Stabilisers	Stabilisers
		Cetylamine hydrofluoride
		Acetone

Department of Microbiology and Department of Anatomy, Post Graduate Institute of Medical Education and Research, Chandigarh.

A total number of 150 M (75 primary molars and 75 permanent molars) were used in the present study.

2.1. Criteria for inclusion of samples

- Primary molars with no caries which were extracted for orthodontic purposes (serial extraction).
- Over retained primary molars with no caries.
- Permanent teeth which were extracted due to peridontal problems.

2.2. Criteria for exclusion of samples

- Deeply carious molars, molars with the exposed pulp.
- Carious lesions involving proximal surfaces of tooth.
- Hypoplastic molars.
- Molars with the internal resorption.

After extraction the teeth were stored in the normal saline at room temperature till the study was conducted.

After retrieving from the normal saline, class I cavities were prepared in each sample with straight fissured diamond burs (KG Sorensen) using a high speed water cooled handpiece. The cavity width represented approximately one third the width of the occlusal table.

A total number (N) of 150 samples (deciduous = 75, permanent – 75), were randomly divided into five equal groups, Group I–V according to the restorative material to be used for class I restorations. Each group consisted of 30 samples.

Each group was further divided into 2 subgroups, A and B. Subgroup A comprised of 15 deciduous molars. Subgroup B consisted of 15 permanent molars. Number of samples per subgroup for statistical evaluation (n) are 15 (Table 2).

2.3. Insertion of Restorative Materials (Table 1)

2.3.1. Group I

Dental glass ionomer filling material (GC FUJI IX GP) (GC Corporation, Tokyo, Japan) was restored in the cavities. It is supplied as powder and liquid. The standard powder to liquid ratio is 3.6 g/1.0 g (1 level scoop of powder to 1 drop of liquid).Powder and liquid were dispensed onto the pad. Using the plastic spatula, the powder was divided into two equal parts. The first portion of the powder was mixed with all the liquid for 10 s and then incorporated the remaining portion of the powder and mixed the whole thoroughly for 15–20 s and the material was transferred to the cavity preparation with cement carrier.

2.3.2. Group ll

Light cured resin reinforced restorative cement (GC Fuji II LC improved) (GC Corporation, Tokyo, Japan) is supplied in powder and liquid forms. The standard powder to liquid ratio is 3.2 g/1 g (1 level scoop of powder to 2 drops of liquid). According to the manufacturer's instructions, the cavities were restored and light cured for 20 s using visible light curing device (3 M Unitek, California, USA).

2.3.3. Group III

Glass ionomer protecting and stabilizing material (GC FUJI VII) (GC Corporation, Tokyo, Japan) which is supplied as powder and liquid, is restored in the cavities according to the manufacturer's instructions. The standard powder liquid ratio is 1.8 g/1.0 g (1 level scoop of powder to 1 drop of liquid).

2.3.4. Group IV

Compomer restorative material (Dyract) (Dentsply, DeTrey GmbH, Germany) was supplied in the capsule form. Prime and Bond NT were dispensed directly onto the applicator tip and ample amount of it was immediately applied to thoroughly wet all the tooth surfaces, kept it for 20 s and then light cured for 10 s. The compomer restorative material was immediately placed over the cured Prime and Bond NT and then it was cured for 40 s.

Final finishing and polishing of the restorations were done using silicon rubber polishers (Shofu Inc., Japan) on a slow speed hand piece and then the varnish (GC Fuji) was applied to seal the area.

The samples were stored in the normal saline at the room temperature for 24 h. The specimens were subjected to 250 cycles of thermocycling between 5 ± 2 °C to 60 ± 2 °C with

Table 2 List of groups and subgroups.

Groups	Subgroups	No. of samples (n)
Group I	Subgroup IA	15 (deciduous)
	Subgroup IB	15 (permanent)
Group II	Subgroup IIA	15 (deciduous)
	Subgroup IIB	15 (permanent)
Group III	Subgroup IIIA	15 (deciduous)
	Subgroup IIIB	15 (permanent)
Group IV	Subgroup IVA	15 (deciduous)
	Subgroup IVB	15 (permanent)
Group V	Subgroup VA	15 (deciduous)
	Subgroup VB	15 (permanent)

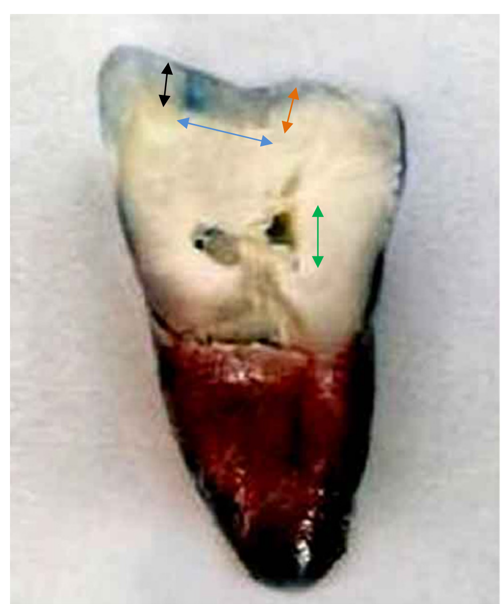

Figure 1 Sectioned sample. ↕ Microleakage showing dye penetration; ↕ pulpal wall of cavity; ↕ bucco-lingual wall of cavity; ↕ pulp chamber of tooth.

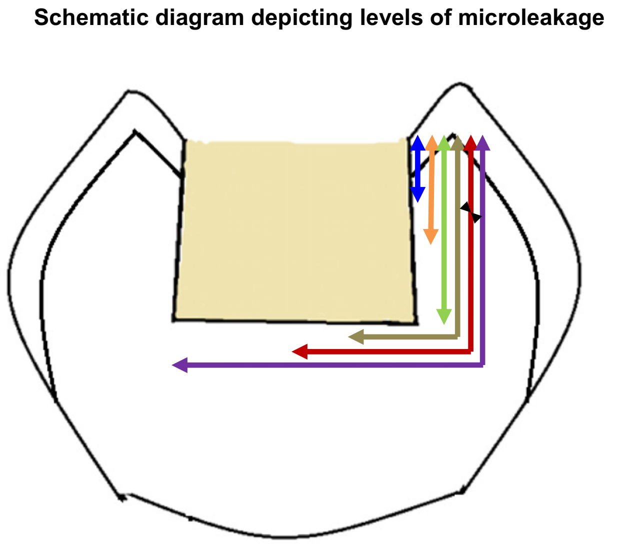

Figure 2 Schematic diagram depicting levels of microleakage. score 1; score 2; score 3; score 4; score 5; score 6.

dwell time of 30 s in each water bath and 10 s interval between the baths.

Two coats of nail varnish were applied to the tooth structure 1 mm short of the restorative margins. The teeth were then stored in 1% methylene blue for 24 h.

After 24 h, the samples were removed from the dye and washed thoroughly with the slurry of pumice to remove the superficial dye. The teeth were then sectioned longitudinally through the centre of the restoration in bucco-lingual plane using a diamond disc (Shofu Inc., Japan) under water spray.

Degree of dye penetration in the occlusal cavity walls was assessed separately under a stereomicroscope at 40 × magnification. The part of the sectioned tooth (Fig. 1) which showed greater amount of microleakage was considered in the study. The following microleakage scores were used to assess the extent of dye penetration at the buccal and lingual walls (Fig. 2).

Table 3 Comparison for the means of microleakage between various groups.

Group	*t*-Value	*P*-Value
I:II	7.089	$P < 0.05^{*}$
I:III	6.572	$P < 0.05^{*}$
I:IV	5.854	$P < 0.05^{*}$
I:V	6.420	$P < 0.05^{*}$
II:III	0.396	$P > 0.05^{**}$
II:IV	0.508	$P > 0.05^{**}$
II:V	18.114	$P < 0.05^{**}$
III:IV	0.809	$P > 0.05^{**}$
III:V	14.340	$P < 0.05^{*}$
IV:V	13.748	$P < 0.05^{*}$

* Significant.
** Non-significant.

Table 4 Comparison for the means of microleakage among subgroups A of each Group.

Subgroup	*t*-Value	*P*-Value
IA:IIA	5.209	$P < 0.05^{*}$
IA:IIIA	4.919	$P < 0.05^{*}$
IA:IVA	4.102	$P < 0.05^{*}$
IA:VA	3.674	$P < 0.05^{*}$
IIA:IIIA	0.140	$P > 0.05^{**}$
IIA:IVA	0.123	$P > 0.05^{**}$
IIA:VA	11.526	$P < 0.05^{*}$
IIIA:IVA	0.232	$P > 0.05^{**}$
IIIA:VA	9.930	$P < 0.05^{*}$
IV:VA	7.776	$P < 0.05^{*}$

* Significant.
** Non-significant.

Occlusal wall:
0: No dye penetration.
1:Dye penetration up to 1/4 (Fig. 7).

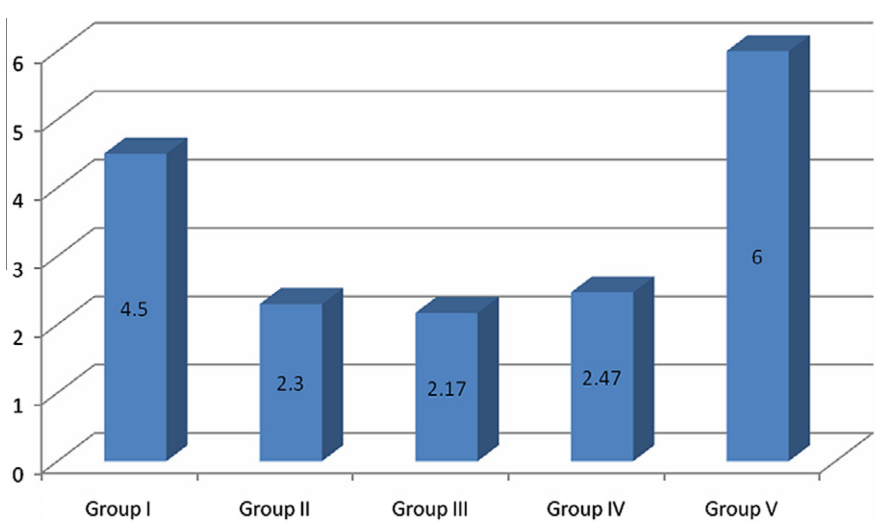

Figure 3 Mean values for microleakage of various groups. Group I: dental glass ionomer filling material (GC FUJI IX GP); Group II: light cured resin reinforced restorative (GC FUJI II LC); Group III: glass ionomer protecting and stabilizing material (GC FUJI VII); Group IV: compomer restorative material (DYRACT); Group V: control (no restorative material used).

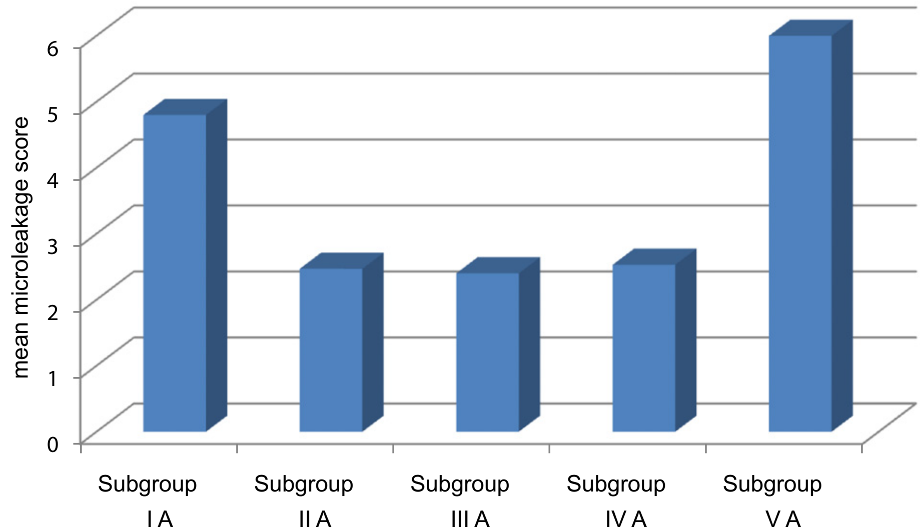

Figure 4 Mean values of microleakage for Subgroup A of various groups. Subgroup IA: dental glass ionomer filling material (GC FUJI IX GP); subgroup IIA: light cured resin reinforced restorative (GC FUJI II LC); subgroup IIIA: glass ionomer protecting and stabilizing material (GC FUJI VII); subgroup IVA: compomer restorative material (DYRACT); subgroup VA: control (no restorative material used).

2:Dye penetration up to 1/2 of buccal/lingual wall (Fig. 8).
3:Dye penetration along the entire buccal/lingual wall (Fig. 9).
4:Dye penetration up to 1/4 of pulpal wall.
5:Dye penetration up to 1/2 of pulpal wall.
6:Dye penetration along entire pulpal wall (Fig. 10).

The data collected were tabulated accordingly and were subjected to statistical analysis (One way ANOVA test and *t*-test).

3. Results

Microleakage for each group was evaluated by Binocular stereomicroscope (Olympus, Japan) and microleakage was recorded using Bui's scale. (Buerett, 2004).

Table 5 Comparison for the means of microleakage among subgroups B of each group.

Subgroup	*t*-Value	*P*-Value
IB:IIB	4.850	$P < 0.05^{*}$
IB:IIIB	4.416	$P < 0.05^{*}$
IB:IVB	4.231	$P < 0.05^{*}$
IB:VB	5.511	$P < 0.05^{*}$
IIB:IIIB	0.415	$P > 0.05^{**}$
IIB:IVB	0.690	$P > 0.05^{**}$
IIB:VB	14.127	$P < 0.05^{*}$
IIIB:IVB	0.971	$P > 0.05^{**}$
IIIB:VB	10.269	$P < 0.05^{*}$
IVB:VB	13.208	$P < 0.05^{*}$

* Significant.
** Non-significant.

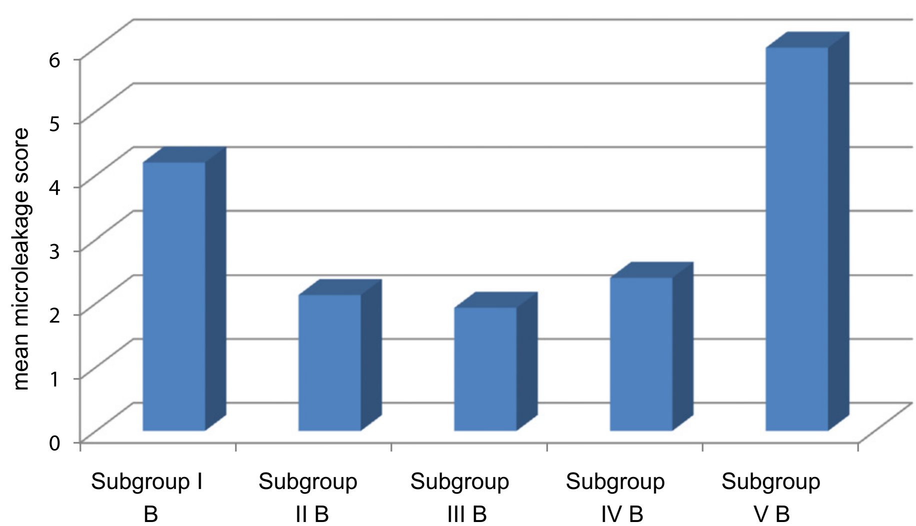

Figure 5 Mean values for microleakage of Subgroups B of various groups. Subgroup IB: dental glass ionomer filling material (GC FUJI IX GP); subgroup IIB: light cured resin reinforced restorative (GC FUJI II LC); subgroup IIIB: glass ionomer protecting and stabilizing material (GC FUJI VII); subgroup IVB: Compomer restorative material (DYRACT); subgroup V B: control (no resrorative material used).

Table 6 Intragroup comparison for the means of microleakage for various Subgroups (subgroup A and B) of various glass ionomer based restorative materials.

Subgroup	*t*-Value	*P*-Value
IA:IB	1.299	$P > 0.05^*$
IIA:IIB	0.811	$P > 0.05^*$
IIIA:IIIB	0.869	$P > 0.05^*$
IVA:IVB	0.255	$P > 0.05^*$

* Non-significant.

Fig. 3 shows the comparison of mean of microleakage values for GC Fuji I, GC Fuji IX GP, GC Fuji II LC, GC Fuji VII, and Dyract and control group.

Table 3 depicts that significant difference ($P < 0.05$) was found when Group I (GC Fuji IX GP) was compared with the other groups viz. GC Fuji II LC (Group II), GC Fuji VII and Dyract (Group IV).

The mean microleakage values for subgroup A (Fig. 4, Table 4), subgroup B (Fig. 5,Table 5) and subgroup A and B (Fig. 6) are shown.

No significant difference ($P > 0.05$) was found, when intragroup comparison of mean of microleakage of various subgroups was done (Table 6).

4. Discussion

Dental glass ionomer filling material (GC Fuji IX GP) exhibited a mean leakage of 4.50 ± 1.27 after 24 h of dye immersion. This was in accordance with the study done by Virmani et al. (2007) who determined the cuspal fracture resistance and microleakage of glass ionomer cement in primary molars and found almost similar microleakage results with GC Fuji IX GP in primary molars. Virmani et al. also concluded that the use of additional application of sealant over the material gave the lowest degree of microleakage.

Owing to the high p/l ratio and reduced glass particle size (13.43 m) Irie et al., 2008 GC Fuji IX GP is highly viscous material. The microleakage behaviour would probably have been due to its high viscosity, not allowing the wetting of the tooth surface properly, preventing the formation of good seal between tooth restoration interface (Castro and Feigal, 2002).

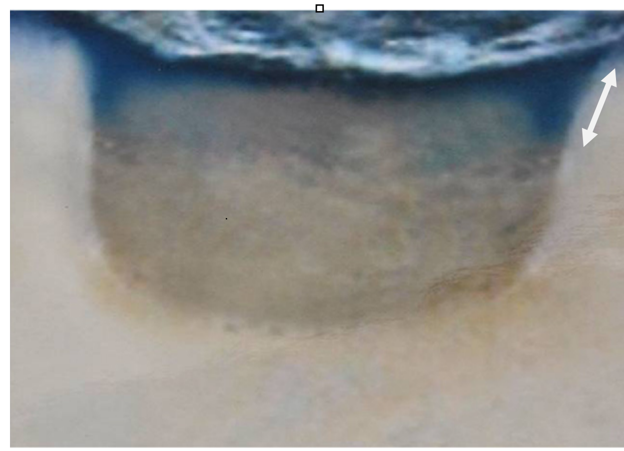

Figure 7 Score 1: microleakage extending along 1/4 buccal wall.

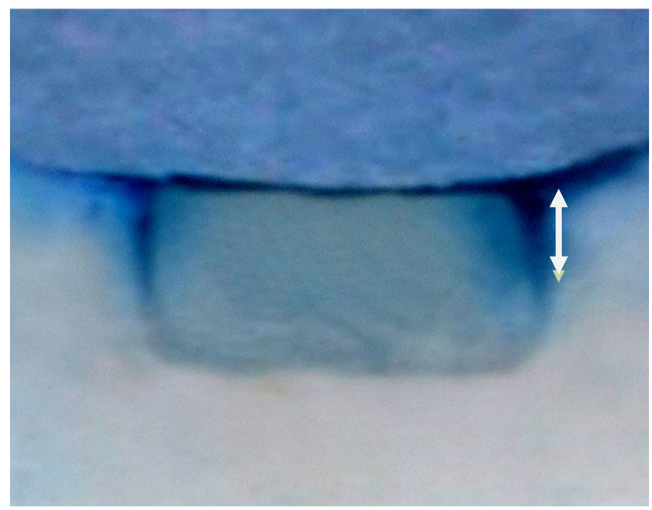

Figure 8 Score 2: microleakage extending along 1/2 buccal wall.

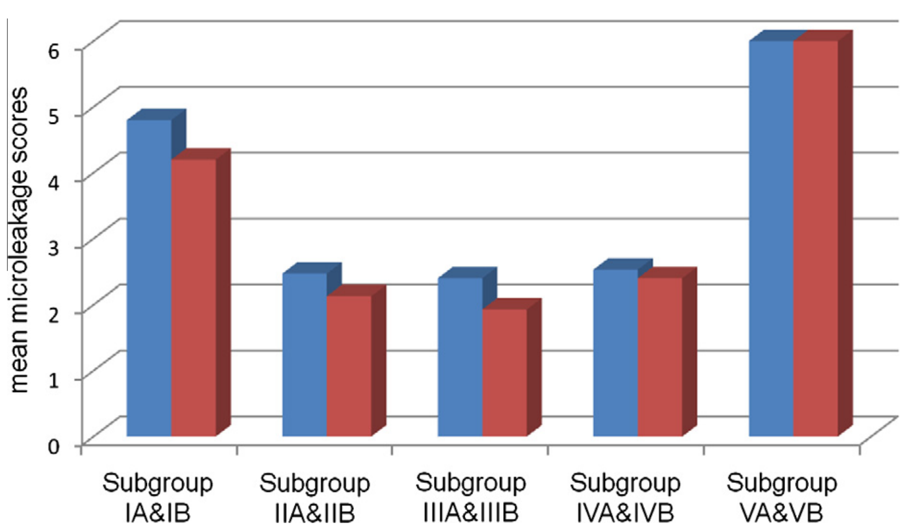

Figure 6 Intragroup comparison for the means of microleakage for various subgroups. Subgroup A ■: deciduous teeth; and subgroup B ■: permanent teeth.

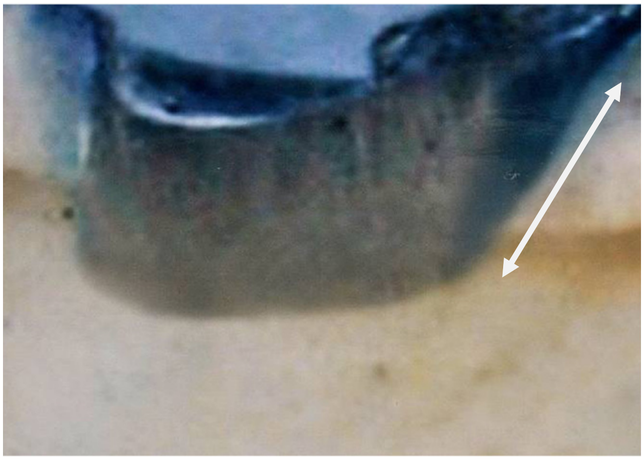

Figure 9 Score 3: microleakage extending along entire buccal wall.

The mean microleakage for the GC Fuji II LC after 24 h of dye immersion was 2.30 ± 1.11. The good sealing ability of light cured resin reinforced restorative cement can be explained on the lines that water sorption, which is the function of the resin components, could have resulted in subsequent expansion of the material which might have decreased marginal gaps between restoration and tooth (Prabhakar et al., 2003).

The mean microleakage for the GC Fuji VII was 2.17 ± 1.46 after 24 h of dye immersion. The most potent sealing ability of GC Fuji VII would have been probably due to low viscosity of the material, which would have been able to wet the tooth surface completely leading to the close adaptation of the restorative cement to the tooth structure and giving a good marginal seal (GC, 2004–2005).

The mean microleakage of compomer was 2.47 ± 1.40 after 24 h of dye immersion. This microleakage pattern would have been attributed to higher resin content (28%) as compared to GC FUJI II LC, which causes more polymerisation shrinkage thereby leading to increased micro leakage.

The coefficient of thermal expansion of Dyract (40.82 ppm/°C) (Taledano et al., 1999) mismatches with the coefficient of thermal expansion of tooth substance (9–11 ppm/°C) which subsequently resulted in increased microleakage. This was in accordance with the study comparing (Prabhakar et al., 2003) the microleakage of compomer to that of conventional and hybrid ionomer.

The smaller micro leakage scores of compomer as compared to GC FUJI IX GP would have been attributed to the fact that compomer is a single component material whereas GC FUJI IX GP requires mixing of the two components. The smaller micro leakage scores of compomer as compared to GC FUJI IX GP might have been due to premeasured capsule of compomers, which obviated the uncertainties in powder/liquid proportion and allowed the consistent mix of the restorative material (Morabito and Defabianis, 1997).

Deciduous molars showed more microleakage than permanent molars but no statistically significant difference was found. This could be attributed to the difference in the composition of deciduous teeth as compared to the permanent teeth.

The mechanism of adhesion of glass ionomer cement to tooth structure involves chelation of carboxylic groups of polyacids with the calcium in the apatite of enamel and dentin. The permanent teeth contain more inorganic content as compared to the primary teeth, leading to the strong bond which in turn might have lead to the decrease in microleakage.

According to Hirayama (1990) who revealed that peritubular dentin of primary teeth is 2–5 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 to the permanent teeth leading to increase in microleakage.

5. Conclusions

1. The microleakage scores for glass ionomer protecting and stabilizing material (GC Fuji VII) were found to be the lowest minimum followed by light cure glass ionomer cement (GC Fuji II LC) and compomer, the difference was statisti-

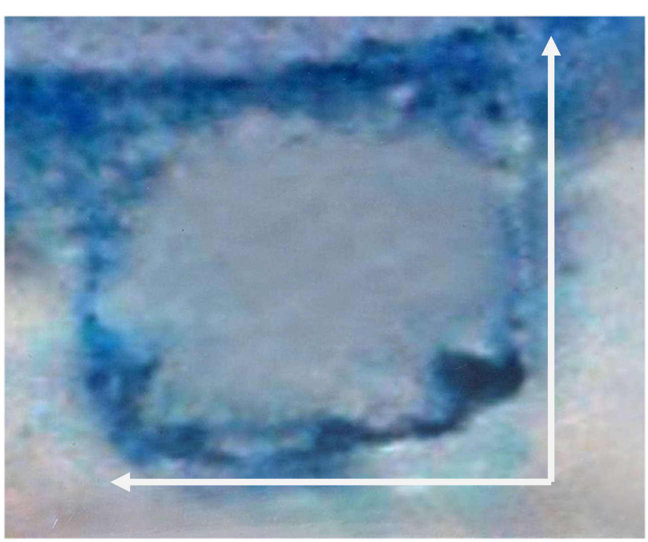

Figure 10 Score 4: microleakage extending along entire buccal and pulpal wall.

cally non-significant. Dental glass ionomer filling material (GC Fuji IX GP) displayed statistically significant lower values as compared to the other restorative materials.

2. Similar results were found when the various glass ionomer based restorative materials were used in deciduous and permanent teeth.
3. The primary teeth showed more microleakage than permanent teeth but statistically there was no significant difference.

Thus the sealing ability in terms of microleakage can be summarised as: Glass ionomer protecting and stabilising material (GC Fuji VII) $\geqslant$ light cured resin reinforced restorative (GC Fuji II LC) $\geqslant$ compomer restorative materials (Dyract) $>$ dental glass ionomer filling material (GC Fuji IX GP) $>$ control.

References

Buerett, J. 2004. A new scale for the quantification of microleakage studies online Sep 1992. <http://www.biomed> (cited Jan 2004).

Castro, A., Feigal, R.F., 2002. Micro leakage of new improved glass ionomer restorative material in primary and permanent teeth. J. Pediatr. Dent. 24, 23–28.

Dutta, B.N., Gauba, K., Tiwari, A., Chawla, H.S., 2001. Silver amalgam versus resin modified glass ionomer cement class II restoration in primary molars. Twelve month clinical evaluation. J. Indian Soc. Prev. Dent. 19, 118–122.

GC. Technical Product Catalogue 2004–2005, GC.

Hirayama, A., 1990. Experimental analytical electron microscopic studies on the quantitative analysis of elemental concentrations biological thin specimens and its application to dental sciences. Shikwa Gakuho 90, 1036–1091.

Hirschfeld, Z., Frenkel, A., Zyskind, D., Fuks, A., 1992. Marginal leakage of class II glass ionomer composite resin restorations: An in vitro study. J. Prosthet. Dent. 67, 148–153.

Irie, M., Marno, Y., Nishgawa, G., Suzuki, K., Watts, D.C., 2008. Class I gap formation in highly viscous glass ionomer restorations: delayed vs. immediate polishing. J. Oper. Dent. 33-2, 196–202.

Morabito, A., Defabianis, P., 1997. The marginal seal of various restorative materials in primary molars. J. Clin. Pediar. Dent. 22910, 51–54.

Prabhakar, A.R., Madan, M., Raju, O.S., 2003. The marginal seal of flowable composite, an injectable resin modified glass ionomer and compomer in primary molars – an in vitro study. J. Indian Soc. Pedo. Prev. Dent. 21 (2), 45–48.

Puckett, A.D., Fitchie, J.G., Denett Beth, J.H., 1995. Microleakage and thermal properties of hybrid ionomer restoratives. Quintessence 26 (8), 577–580.

Sikri, V. (Ed.), 2002. Microleakage. A Textbook of Operative Dentistry. Arya Publications, Delhi.

Taledano, M., Osorio, R., Gauia, G.F., 1999. Microleakage of class V resin modified glass ionomer and compomer restorations. J. Prosthet. Dent. 81, 610–615.

Virmani, S., Tendon, S., Rao, N., 2007. Cuspal fracture resistance and microleakage of glass ionomer cements in primary molars. J Clin Pediatr Dent 22, 55–58.