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Original Article

Dentistry Section

Sealing Ability of Three Different Surface Coating Materials on Conventional and Resin Modified Glass Ionomer Restoration in Primary Anterior Teeth: An In vitro Study

ANSHULA DESHPANDE[1], CHIRAG MACWAN[2], STEFFI DHILLON[3], MEDHA WADHWA[4], NEELAM JOSHI[5], YASH SHAH[6]

ABSTRACT

Introduction: Microleakage is an important property that has been used in assessing the success of any restorative material used in restoring a tooth. Immediate application of a surface coating agent is suggested to protect glass ionomer cement against moisture contamination and dehydration during early setting.

Aim: To compare marginal microleakage of two different Glass Ionomer Cement (GIC)- Conventional GIC and Resin Modified GIC in primary anterior teeth using three surface coating materials.

Materials and Methods: An in vitro study was conducted between January 2014 to October 2017 on freshly extracted 40 anterior primary teeth which were randomly assigned into two main groups (Fuji II GIC and Fuji II LC GIC) with four subgroups (control-no surface coating, A=GC Fují Varnish II, B=GC G-Coat Plus, C=Icon). A standardised Class V cavity preparation was prepared on the labial surface of each tooth. Specimens were coated with two layers of nail varnish, leaving a 1 mm window around the cavity margins and placed in a solution of Methylene blue Dye for 24 hour at 37°C. The teeth were sectioned longitudinally in a buccolingual direction of the restorations and evaluated under stereomicroscope to check extent of dye penetration. The results were analysed by ANOVA and Tukey's post-hoc test ($p \leq 0.05$).

Results: It was found that maximum microleakage was seen in group 1 (Fuji II GIC) as compared to group 2 (Fuji II LC GIC) and it was non-significant ($p=0.53$). Ascending order for mean microleakage for Group 1 was as follows: Control >GC Fuji Varnish >Icon DMG >GC G-Coat and for Group 2: Control >GC Fuji Varnish >Icon DMG >GC G-Coat. Icon when compared with Gc coat and Varnish also showed non-significant ($p=0.137$) difference in Group 2.

Conclusion: All three different surface coatings can seal glass ionomer restorations. The GC G-Coat Plus has the least microleakage on Resin-Modified GIC (RMGIC) compared to the other surface coatings. This would aid the clinicians to make appropriate decision regarding the choice of material to be used for restoration and coating in anterior primary teeth.

Keywords: Dental leakage, Dental marginal adaptation, Fuji II LC cement, Glass ionomer cements, Primary molars

INTRODUCTION

Restorative treatment is based on clinical examination and is preferably part of a comprehensive treatment plan. Tooth preparation should involve removing caries or poorly formed or unhealthy tooth structure in order to create a suitable outline, resistance, retention and convenience form compatible with the restorative material to use [1].

Since its introduction in 1972, glass ionomers have been used as restorative cements in Paediatric dentistry. The original glass ionomer materials were difficult to treat, had low resistance to wear and were brittle. Advances in the formulation of glass ionomers led to improved properties including the development of resin-modified glass ionomers [2]. These products demonstrated improved handling characteristics, reduced setting time, increased strength and increased wear resistance. The RMGICs are known to adhere successfully to enamel; however, contraction forces when applied during light irradiation may lead to bond failure between RMGICs and dentine.

Glass ionomers have many properties that make them ideal for use in children as they are chemically related to both enamel and dentine; their biocompatibility; fluoride uptake and release and decreased sensitivity to moisture compared to resins. The conventional GIC has limitations such as low wear resistance and brittleness, poor strength, surface roughness and moisture susceptibility, which restrict its usage [3,4].

Water plays an important role in setting of GIC. It is responsible for transport of calcium and aluminium cations which react with polyacid and forms polyacrylate. More incorporation of water causes translucency in restoration and causes chalky appearance and microscopic cracks after drying which leads to microleakage [5].

Retentive ability of restorative material to seal tooth-restoration interface from oral fluids and micro-organism and it's property to adhere to the wall of the tooth has always been open discussion for dental practitioners. In clinical dentistry, microleakage is a major concern for dental restorative materials. It is the passage of micro-organisms, fluids, chemicals, ions, and even air between the cavity walls that have been prepared and the restorative materials used for restoration [6]. Microleakage is an important factor which can have detrimental effect on the success of restoration leading to failure, resulting to hypersensitivity of restored teeth, tooth discolouration, recurrent cavities, pulpal damage and rapid degradation of particular restorative materials [7,8]. The majority of cervical lesions exhibit mixed cavity margins positioned in both enamel and dentine [9].

Early moisture contamination weakens GIC restorations making it's surfaces more susceptible to erosion and abrasion, hence isolation is must to avoid microleakage at the time of restoration. Various surface coating agents that are used to prevent microleakge are petroleum jelly, cocoa butter and varnishes. However, these coatings wear off from the restoration in due course of time. Light polymerised resin coatings have been found to be most optimal surface protecting agent [5,10]. Various manufacturers recommended coating products such as GC G-Coat Plus, GC Varnish, GC Fuji Coat LC and Copal varnish. These coatings inhibit water adsorption, minimise surface irregularities and enhance aesthetics of restoration. Resin infiltrate such as Icon (DMJ, USA) is micro-invasive and can be used to minimise the microleakage at tooth-restoration interface. Till date, there has been dearth of studies that compare and evaluate effects of various surface coating agents and resin infiltrate on microleakage of various Glass Ionomer cements (accessed Medline®, Ovid®, EBSCO host database on 02.06.2020).

So, this in vitro study was undertaken to compare sealing ability of different surface coatings on conventional Glass Ionomer and resin modified glass ionomer restoration for microleakage prevention.

MATERIALS AND METHODS

This in vitro study was carried out between January 2014 to October 2017 in K.M Shah Dental College and Hospital, Vadodara, Gujarat, India, after approval by the institution's Research Ethics Committee (SVIEC/ON/Dent/RP/1380).

Sample Description

Minimum sample size required for the study was 40 freshly extracted anterior primary teeth with 95% confidence interval and 80% power [11].

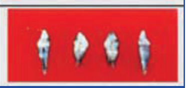
All teeth underwent surface debridement with hand scaling instrument, cleaned with a rubber cup and slurry of pumice, disinfected in 0.5% chloramine and subsequently stored in distilled water at 37°C until use [12]. There are various morphogenic differences between primary and permanent teeth, as the primary teeth has thin enamel covering and higher pulp horns, it is important to prevent microleakage. Hence, it is important to evaluate efficacy of surface coating on restored primary teeth.

A standardised Class V cavity was prepared by co-investigator on the labial surface of each tooth. Preparations were made with an SF 12C cylindrical diamond bur (Mani INC, Tochigi, Japan) under air-water cooling. The bur was replaced after ever four preparations. The dimensions of the preparations measured were 3 mm in length, 2 mm in width, and 2 mm in depth with the incisal margin in enamel and the gingival margin in dentine using a William's graduated periodontal probe (Hu-Friedy, Chicago, IL, USA). The teeth were prevented from dehydration by immersing in distilled water at room temperature when not being prepared for restoration. Forty extracted teeth were divided into 2 groups (FUJI II GIC, FUJI II LC GIC), teeth were further subdivided into four groups (control-no surface coating, A=GC Fuji Varnish II, B=GC G- Coat Plus, C=Icon) as given in [Table/Fig-1,2].

Groups	Restoration	Sub groups	Surface coating
Group-I	Fuji II GIC (n=20)	Control	No surface coating
		A	GC Fuji Varnish II (GC Corporation, Tokyo, Japan)
		B	GC G-Coat Plus (GC Corporation, Tokyo, Japan)
		C	Icon (DMG, Hamburg, Germany)
Group-II	Fuji II LC GIC (n=20)	Control	No surface coating
		A	GC Fuji Varnish II (GC Corporation, Tokyo, Japan)
		B	GC G-Coat Plus (GC Corporation, Tokyo, Japan)
		C	Icon (DMG, Hamburg, Germany)

[Table/Fig-1]: Sample Distribution of extracted primary teeth in two different groups.

After that, GC Dentine Conditioner (GC Corporation, Tokyo, Japan) was applied on the cavity wall with a pellet for 20 seconds, rinsed with water and dried without desiccating. The manufacturer's instructions were followed properly for powder/liquid proportioning and mixing of restorative materials before placing them into the cavity.

GROUPS		Group 1	Group 2
Sub Groups	Surface Coating	Fuji II LC GIC	Fuji II LC GIC
Control	No Surface Coating		
A	GC Fuji Varnish II		
B	GC G-Coat Plus		
C	Icon(DMG,Germany)		

[Table/Fig-2]: Random allocation of extracted primary teeth in different groups.

A transparent mylar matrix (Clear Thru; Premier Dental Products, Norristown, PA, USA) was adapted over GIC Fuji II restorations during the initial setting for 2 minutes, and Fuji II LC GIC was cured with an LED curing unit (Star Light Pro; Mectron Medical Technology, GE, Italy) for 20 seconds. After that, the matrix was removed, and the restorations were covered with coating material according to group and manufacturer's instructions. A BP knife was used to remove any excess material. Teeth were preserved in artificial saliva (0.4g NaCl-0.4g KCl-0.795 g $CaCl_2.2H_2O$-0.69 g Na_2HPO_4-0.005 g $Na_2S.\ 9H_2O$-1 g Urea+1 L Deionised water) with pH 7.03 at body temperature for 24 hours after the coating substance had dried [13]. Following that, all of the teeth were submitted to a 500-cycle thermocycling regimen between 5°C and 55°C, with a dwell duration of 1 minute and 3 second between baths.

Application of resin infiltration coating material: Firstly, 15% hydrochloric acid gel (ICON-Etch; DMG; Hamburg, Germany) was applied for 120 seconds followed by etchant application. It was rinsed for 30 seconds and Ethanol lesion desiccation (ICON-Dry; DMG®) was applied for 30 seconds, accompanied by drying. Then infiltrate resin (ICON-Infiltrate; DMG®) was applied for three minutes. In the last phase infiltrant resin was light cured for 40 seconds [14].

Preparation of samples for microleakage: Two coats of nail varnish were applied to the specimens, leaving a 1 mm window across the cavity margins. To avoid desiccation, a damp cotton pellet was applied over the restoration during the application of nail varnish. Teeth were inverted and incubated for 24 hours at 37°C in a solution of Methylene blue dye (Triveni Aromatics and Perfumery Private Limited, Vapi, India). The dye was only applied to the coronal section of the teeth to avoid leakage through the root apices. The surface adhered dye was rinsed in tap water after the specimens were separated from the dye solution, and nail varnish was removed with a BP blade [15].

Using a water-cooled low speed diamond disc, the teeth were sectioned longitudinally in a buccolingual direction through the centre of the restorations (Horico, Berlin, Germany). Two evaluators who were blinded to the study groups tested the section with the greatest leakage using a stereo microscope (OZL-45, Kern, Balingen, Germany) at 25x magnification to assess dye penetration at the occlusal and gingival margins.

Dye scoring criteria: The depth of dye penetration was analysed according to a 0-3 scale scoring system as suggested by Silveira de Araújo C [Table/Fig-3] [16].

Score 0	No evidence of dye penetration
Score 1	Dye penetration along the occlusal/gingival wall to less than half of the cavity depth
Score 2	Dye penetration along the occlusal/gingival wall to more than half of the cavity depth, but not extending on to the axial wall
Score 3	Dye penetration along the occlusal/gingival wall to the full cavity depth and extending on to the axial wall.

[Table/Fig-3]: Dye scoring criteria suggested by Silveira de Araújo C [16].

STATISTICAL ANALYSIS

The collected data was entered in Microsoft excel (2007) spreadsheet. Descriptive statistical tests were computed using excel statistical operations. Inferential statistics were done using SPSS version 21.0. Intraexaminer reliability was evaluated at 95% confidence interval using Cohen's kappa coefficient (κ), it was found to be 0.80. ANOVA and Tukey's post-hoc test were used and the p-value less than or equal to 0.05 was assumed to be statistically significant.

RESULTS

In the present study, dye scoring criteria was used based on 0-3 scoring system by Silveira de Araujo C [16] but for the ease of its application in statistical analysis (µm) was used for depth penetration. Dye penetration score for each sample is depicted in [Table/Fig-4].

Coating materials	Group-I Fuji II GIC (n=20)	Group-II Fuji II LC GIC (n=20)
	Score	Score
Control (n=10)	3	3
	3	3
	3	3
	3	2
	2	2
GC Fuji Varnish II (n=10)	2	2
	2	1
	2	2
	2	2
	2	2
GC G-Coat Plus (n=10)	0	0
	0	0
	0	0
	1	0
	1	1
Icon (DMG, Germany) (n=10)	2	0
	1	2
	1	1
	1	1
	1	1

[Table/Fig-4]: Dye penetration score for individual sample of conventional glass ionomer cement and resin modified glass ionomer cement.

Microleakage score was measured at the occlusal and gingival margins and among them higher microleakage values were considered for statistical analysis. Mean microleakage and standard deviation of two types of glass ionomer is described in [Table/Fig-5]. Fuji II GIC group and Fuji II LC showed 1.60 µm and 1.40 µm mean microleakage respectively but that was not statically significant (p=0.53). Comparison of microleakage of different coating agents on glass ionomer cement among two groups revealed GC Fuji varnish have significant difference than other coating materials (p=0.02) [Table/Fig-6].

ANOVA test was carried out to compare the microleakage of coating materials and control group in Fuji II GIC and Fuji II LC. The difference was found to be highly significant [Table/Fig-7]. Further, the tukey's post hoc analysis was carried out.

In Group-I, GC-G coat showed significant difference compared with control group (p>0.001), with GC Fuji Varnish group (p>0.01) and with Icon DMG group (p=0.036). GC Fuji varnish group (p=0.036) and Icon DMG group (p>0.01) showed statistically significant difference in comparison with control group [Table/Fig-8]. Marginal microleakage of various surface coating agent on FUJI II GIC cement is as follows: Control (2.8) >GC Fuji Varnish (2) >Icon DMG (1.2) >GC G-Coat (0.4). In Group-II also, GC G-Coat showed significant difference compared with control group (p>0.001) and GC Fuji Varnish group (p=0.001). Icon DMG showed significant difference when compared with control group (p>0.001) [Table/Fig-9]. Marginal microleakage of various surface coating agents on FUJI II LC GIC cement is as follows: Control (2.6) >GC Fuji Varnish (1.8) >Icon DMG (1) >GC G Coat (0.2).

	Groups	N	Mean (µm)	Std. Deviation	Std. Error mean	p-value*
Microleakage	Fuji II GIC	20	1.60	0.99	0.22	0.53
	Fuji II LC GIC	20	1.40	1.04	0.23	

[Table/Fig-5]: Comparison between the conventional glass ionomer cement and resin modified glass ionomer cement based on mean microleakage.
N: Number; *Independent t-test (p≤0.05)

Groups		Mean micro-leakage (µm)	Standard deviation	p-value*	95% Confidence interval	
					Lower bound	Upper bound
Control Group	Fuji II GIC	2.8	0.44	0.25	-0.52	0.92
	Fuji II LC GIC	2.6	0.54			
GC Fuji Varnish	Fuji II GIC	2	0.0	0.02*	-0.26	0.62
	Fuji II LC GIC	1.8	0.44			
GC G Coat	Fuji II GIC	0.4	0.54	0.25	-0.52	0.92
	Fuji II LC GIC	0.2	0.44			
Icon DMG	Fuji II GIC	1.2	0.44	0.78	-0.66	1.06
	Fuji II LC GIC	1	0.70			

[Table/Fig-6]: Intergroup comparison of various coating materials used among conventional glass ionomer cement and resin modified glass ionomer cement.
*Independent t-test (p≤0.05)

	Sum of squares	df	Mean square	F	p-value*
Between groups in Fuji II GIC	16.000	3	5.333	30.476	0.000
Between groups in Fuji II LC GIC	16.000	3	5.333	17.778	0.000

[Table/Fig-7]: Comparision of microleakage in three coating materials and control group in Fuji II GIC and Fuji II LC GIC.
*ANOVA test

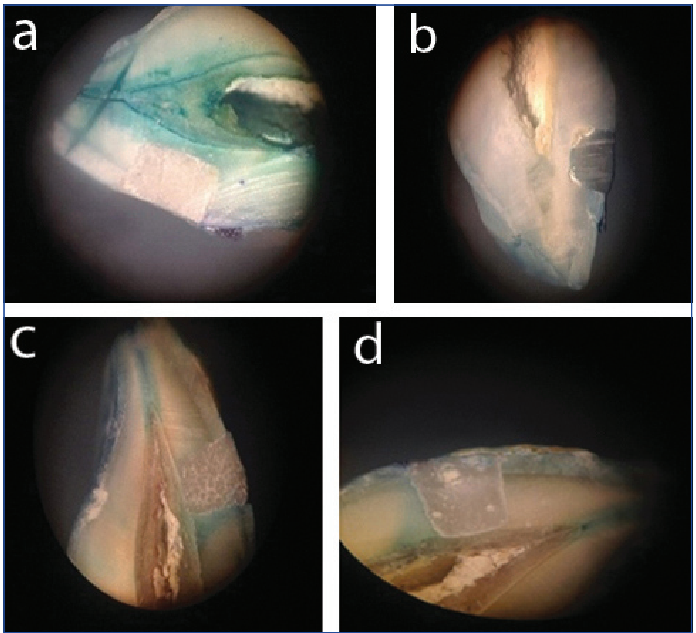
Groups (I)	Groups (J)	Mean difference (I-J)	Std. Error	p-value*	95% Confidence interval	
					Lower bound	Upper bound
Control	A (Varnish)	0.800	0.264	0.036*	0.0430	1.5570
Control	B (GC G-coat)	2.400	0.264	>0.001*	1.6430	3.1570
Control	C (Icon DMG)	1.600	0.264	>0.001*	0.8430	2.3570
A (Varnish)	B (GC G-coat)	1.600	0.264	>0.001*	0.8430	2.3570
A (Varnish)	C (Icon DMG)	0.800	0.264	0.036*	0.0430	1.5570
B (GC G-coat)	C (Icon DMG)	-0.800	0.264	0.036*	-1.5570	-0.0430

[Table/Fig-8]: Tukey's post-hoc test values for comparison of microleakage between different coating materials in Fuji II GIC Groups.
*Tukey's post-hoc test (p≤0.05); I: 1st group; J: 2nd group; (I-J): Mean difference between 1st and 2nd group

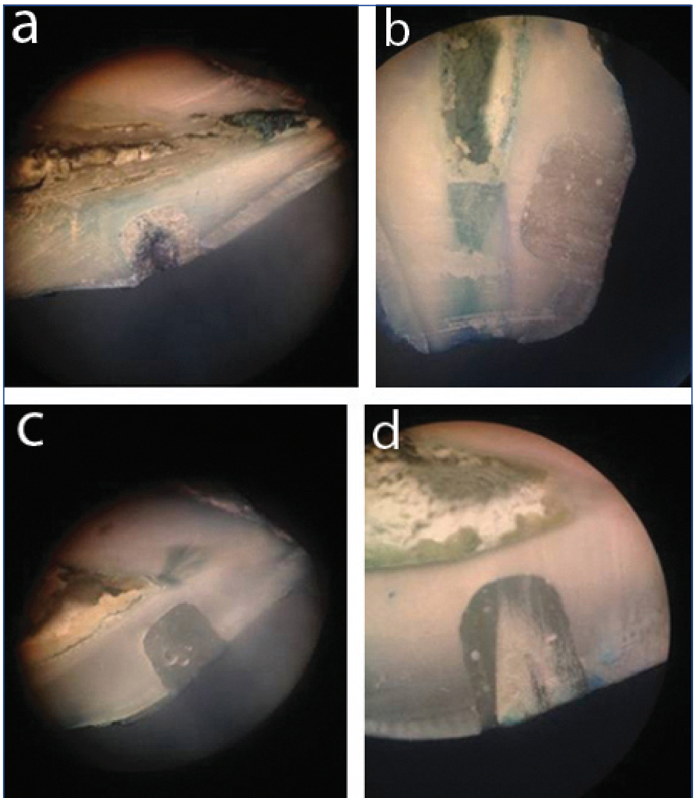
Stereo microscope result: Microleakage was assessed using stereomicroscope at 25x magnification to measure dye penetration. It was found that GC G-Coat Plus has less microleakage between the tooth structure and cement compared to other two tested coating materials [Table/Fig-10,11].

Group (I)	Group (J)	Mean difference (I-J)	Std. Error	p-value*	95% Confidence interval	
					Lower bound	Upper bound
Control Group	A (Varnish)	0.800	0.346	0.137	-0.191	1.791
Control Group	B (GC G-coat)	2.400	0.346	>0.001*	1.409	3.391
Control Group	C (Icon DMG)	1.600	0.346	0.001*	0.609	2.591
A (Varnish)	B (GC G-coat)	1.600	0.346	0.001*	0.609	2.591
A (Varnish)	C (Icon DMG)	0.800	0.346	0.137	-0.191	1.791
B (GC G-coat)	C (Icon DMG)	-0.800	0.346	0.137	-1.791	0.191

[Table/Fig-9]: Tukey's post-hoc test values for comparison of microleakage between different coating materials in Fuji II LC GIC Group.
*Tukey's post-hoc test ($p \leq 0.05$); I: 1st group; J: 2nd group; (I-J): Mean difference between 1st and 2nd group



[Table/Fig-10]: Stereo microscope 25x magnification micrograph of marginal adaptation of Fuji II LC GIC; a: Control Group; b: GC Fují Varnish II; c: GC G- Coat Plus; d: Icon.



[Table/Fig-11]: Stereo microscope 25x magnification micrograph of marginal adaptation of Fuji II GIC; a: Control Group; b: GC Fují Varnish II; c: GC G- Coat Plus; d: Icon.

DISCUSSION

Water plays a key role in the maturation of GIC, dehydration and water contamination can affect the physical properties of restoration during the initial setting stages [17]. GIC restorations when contaminated with moisture, their mechanical strength decreases and the surface material quickly erodes or wears off. A key factor in clinical success is the ability of glass ionomer to minimise the extent of microleakage at the tooth or restoration interface. Due to variations in thermal expansion coefficient values, microleakage can occur between the tooth and restoration interface.

The current study investigated the microleakage of various types of GIC after application of surface coating agents on Class V restorations. Polymerisation shrinkage of restorative material leads to staining, recurrent caries and restoration failures [18]. Microleakage is an important property used to evaluate the success of any material used in tooth restorations [8]. Dennison JB and Sarrette DC, found that Clinical microleakage (penetrating margin discoloration) leads to caries development and is an indication for restoration replacement [1]. Hilton TJ evaluated secondary caries, marginal discoloration and marginal gap/fracture account and found that improving the seal will lead to enhanced restoration longevity [19]. Microleakage was seen in the teeth with cavosurface margins during tooth preparation by Retief DH in 1994 [20]. It has been suggested that cement must be coated with a water proof surface coating as soon as possible to prevent microleakage at the tooth restoration interface. Thermocycling is a standard protocol in the restorative literature when bonded materials are evaluated simulating in vivo aging by subjecting bonded materials to cyclic exposures of hot and cold temperatures. So, in present study thermocycling was used [21]. In this study, concentration of dye penetration into the specimens was measured after 24 hours of storage in the dye solution, since the cross-linking process takes one day to complete after mixing [22].

Surface safety with different surface coating agents such as cocoa butter, waterproof varnish, and even nail varnish was recommended in the early stages of GIC [10]. Earl MS et al., discovered that immediately coating immature GIC with a light-cured bonding resin is the most efficient way to prevent water from spreading over the surface [23]. In 2001, Chuang SF et al., investigated the effect of various surface protections on the margin microleakage of resin-modified glass ionomer cement restorations and discovered that resin adhesive can be used as a surface defence to reduce margin microleakage [24]. Products such as GC G-Coat Plus, GC Varnish, GC Fuji Coat LC and Copal varnish were used for the surface coating to reduced microleakage. These coatings protect the material against water intrusion in the early stages of setting and eliminate surface irregularities as well as improve aesthetics of the restorations.

The GC Fuji Varnish™ is effective as a surface protectant. This finding is similar to study done by Nicholson JW and Czarnecka B which concluded that the application of varnish led to reduction in water loss irrespective of the fact whether the varnish applied was an unsophisticated varnish or a more chemically advanced light curable formulation [25]. The better performance of GC G-Coat Plus as compared to Vaseline® can be attributed to its property of sealing the micro-gaps with nanosized filler particles [26]. In contrary study done by Ninawe N et al., found that Vaseline was considered best surface protecting agent in comparison with G-Coat plus and GC Fuji Varnish [27]. Mensudar R and Sukumaran VG found that samples which were protected with light cured self-adhesive coating (GC G-Coat Plus) exhibited an increased mechanical strength compared to unprotected samples [18]. Espigares J et al., in 2018 evaluated efficacy of low viscosity resin and GC G-Coat Plus to reseal marginal gap and found that resin infiltration can be used as resealing material for restoration with open margins [28]. In this study, there was a statistically significant difference between GC

G-Coat and Icon DMG for FUJI II GIC, but no statistical difference for FUJI II LC GIC. While Icon DMG was found to be effective as a surface protecting agent, it has some drawbacks, including a higher cost than G coat, more steps needed for application of icon making it more time consuming, more advanced armamentarium necessary for application, and one of the steps in Icon technique is the application of etching agent, so isolation is also essential. So, GC G-Coat plus is more suitable for surface coating in comparison with Icon DMG.

In this study, statistically significant difference was observed between the control group and GIC coating with GC G-Coat. Marginal microleakage observed on both FUJI II GIC and FUJI II LC GIC was least after application of GC G-Coat when compared to GC Fuji Varnish and Icon DMG. Curing light utilises the power output in range of 1100-1200 mW/cm^2 which affect the depth of dye penetration of light cure resin. Curing light can provide a sufficient quantity of heat which is believed to speed up the setting reaction in the surface layers and help to strengthen the structure [29].

Feilzer AJ et al., and Bourke AM et al., found that changes in dimension and hardening of surface was observed after initial photocuring and further contraction continues for 24 hours as the material set [30,31]. Gupta SK et al., compared microleakage between conventional GIC, nano filled GIC and resin modified GIC and concluded that nano filled GIC showed least microleakage [32].

Vishnurekha C et al., found a substantial reduction in microleakage in conventional GIC and RMGIC with G Coat plus protective compared to non protective coating and improved the colour stability of cements with the use of light cured protective coating [33]. Tyagi S et al., compared GC Fuji Varnish™, G-Coat Plus™ and EQUIA® Coat and found that all three agents were equally successful in comparison [34].

Bobotis HG et al., and Leinfelder KF observed reduced or minimal microleakage after the use of light cure glass inonomer cement as a restorative material [35,36]. Prabhakar AR et al., conducted the study to compare marginal microleakage of flowable composite, an injectable resin modified glass ionomer and a compomer and found that sealing capacity was explained on the basis of water sorption, which is the role of the resin components, could have led to the subsequent expansion of the product, which could have reduced marginal gaps between restoration and tooth [37].

Limitation(s)

The present study had the limitation of recording the effect of surface protectant for only 24 hours. Also, it did not recognise the effect of different finishing agents on the dye penetration and the effect of surface protective agents on fluoride release. Small sample size was also another limitation of the study.

CONCLUSION(S)

Restoration using resin modified glass ionomer cement showed low marginal microleakage at tooth restoration interface in comparison with conventional glass ionomer cement in primary teeth. Surface coating showed that good sealing ability prevents desiccation or moisture contamination.

The GC GC G-Coat was determined to be the most effective surface coating agent, followed by Icon DMG, based on marginal microleakage of various surface coating agents on Fuji II GIC cement and Fuji II LC GIC cement. This would aid the clinicians to make an appropriate decision regarding the choice of material to be used for restoration and coating in anterior primary teeth to increase the life span of the restoration and further limit the caries progression.

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PARTICULARS OF CONTRIBUTORS:

1. Professor, Department of Paediatric and Preventive Dentistry, KM Shah Dental College and Hospital, Vadodara, Gujarat, India.
2. Former Postgraduate Student, Department of Paediatric and Preventive Dentistry, KM Shah Dental College and Hospital, Vadodara, Gujarat, India.
3. Former Postgraduate Student, Department of Paediatric and Preventive Dentistry, KM Shah Dental College and Hospital, Vadodara, Gujarat, India.
4. Assistant Professor, Department of Management, Sumandeep Vidyapeeth, Vadodara, Gujarat, India.
5. Senior Lecturer, Department of Paediatric and Preventive Dentistry, Manubhai Patel Dental College and Hospital, Vadodara, Gujarat, India.
6. Postgraduate Student, Department of Paediatric and Preventive Dentistry, KM Shah Dental College and Hospital, Vadodara, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Anshula Deshpande,
Department of Paediatric and Preventive Dentistry, KM Shah Dental College and Hospital, Sumandeep Vidyapeeth (Deemed to be University), Piparia, Ta. Waghodia, Vadodara-391760, Gujarat, India.
E-mail: dranshula@gmail.com

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