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IP International Journal of Medical Paediatrics and Oncology

Journal homepage: https://www.ijmpo.com/

Original Research Article

Comparative evaluation of marginal microleakage of various restorative materials used in pediatric dentistry – An in-vitro stereomicroscopic study

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A R T I C L E I N F O

Article history:
Received 09-11-2022
Accepted 22-12-2022
Available online 03-05-2023

Keywords:
CentionN
Glass ionomer cement
Class I cavity
Filtek Z350
and microleakage

A B S T R A C T

Aim: The longevity of restorative materials depends on the resistance to masticatory forces. The present study was undertaken to evaluate the microleakage properties of different restorative materials.
Materials and Methods: A total of 30 specimen blocks were prepared with 10 samples of each type of restorative material, namely GIC Fuji IX, Filtek Z-350 Composite, and Cention-N. Class I cavities were prepared with dimensions 1.5 x 2 x 2 mm (l x b x h) of cavity size of orthodontically extracted premolars followed by restoration of each test material.
Results: We found that Cention-N has shown the least microleakage as compared to other groups.
Conclusion: Mean microleakage was the least for Cention-N. It's a newer restorative material having higher mechanical properties with lesser microleakage.
Clinical significance: Cention-N is a newer restorative material having promising properties. This material can be used as an alternative restorative material.

1. Introduction

Dental caries has been considered a historically important component of the global oral disease burden. Thus, the quest for an ideal restorative material with optimum physical properties and durability exists.[1]

Over the past years, dentistry has shown considerable progress leading to the development of several restorative materials with improved properties. One of the major requisites for the longevity of restoration is its ability to adapt to the cavity walls, the failure of which would lead to microleakage.[2] Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between a tooth and the restorative material.[2]

The causes for microleakage are a poor adaptation of restorative materials, contraction during setting, non-adherence to the tooth structure, deformation under load, and temperature-induced volume changes.[3,4]

Microleakage is determined by many in-vitro studies with or without thermocycling, staining, stereomicroscope, chemical agents, marker neutron activity, and radioisotope adsorption. In stereomicroscopic studies, the method is based on the interpretation of the leakage of the dye on the cavity wall and is defined as a semi-quantitative approach where the leakage is calculated solely at the surface where the sectioning is done.[5]

The marginal gap leads to the bacterial passage at the micron level. There are many factors that cause microleakage e.g. Polymerization shrinkage, thermal expansion, water absorption, and long-term mechanical load. The thermal changes cause elastic deformation and physical alteration in both teeth and the restoration.[6] There are various methods to detect microleakage:(I) Air pressure method (II) Penetration studies (a) Dye penetration

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https://doi.org/10.18231/j.ijmpo.2023.001

(b) Chemical tracers' (c) Radio isotopes (d) Neutron activated analysis (e) Bacterial toxins and bacterial products (f) Chemical diffusion technique (III) Fluid conduction studies (a)Fluid transport device (IV) Electronic method (a) Electrochemical studies (b) Electronic monitoring of microleakage (V) Microscopic examination (a) Scanning electron microscope (b). Replication and SEM (c) Fluorescent microscopy (d) Confocal microscope. The most effective method of evaluating microleakage is dye penetration or chemical tracers as penetration is high between the tooth restoration interfaces.[7]

The ideal restorative material must be easy to manipulate, have a certain amount of adhesion to the tooth structure, should not dislodge easily, and provide good strength and sealing ability. In addition, it must have adequate strength and wear properties, and should not be moisture sensitive during placement and setting.[6]

A high variety of restorative materials are available in today's modern dental practice – from amalgams to modern bulk-fill composites. Amalgam materials were first introduced to western dentistry in the 19th century, Glass ionomer cement (GICs) was introduced in 1the 960s by Wilson and Kent, Composite resins became standard during the late 1960s, Resin modified glass ionomers and compomers were introduced in the 1990s and in a current decade, there is the launch of several bulk-fill composites.[6,7]

Amalgam was universally used for load-bearing areas and contains mercury as one of its constituents. It has good wear resistance, low technique sensitivity, acceptable life expectancy, and low cost. However, it has certain disadvantages such as unacceptable metallic grey color, lack of adhesive properties, making undercuts for mechanical retention necessary, mercury toxicity, and most importantly, lack of marginal adhesive properties.[8]

Glass ionomer cement (GICs) were introduced by Alan Wilson and Brian Kent in early 1970.[6] The major advantage is fluoride release and the ability to adhere to the mineralized tooth structure. The new generation glass ionomer cement GC FUJI IX has recently come into play. It is easy to apply as it does not require additional bonding systems due to low viscosity and can be finished and polished in a single visit.[9] It can be used in geriatric and pediatric patients. However, even GIC Fuji IX has a certain amount of microleakage, along with a lack of sufficient strength and toughness.[6,7,9–17]

Composites became standard during the late 1960s. It has great performance, excellent aesthetics for anterior restorations, high strength for posteriors, unsurpassed fluorescence, and imitates nature better than all other restorative materials. A major drawback of composites is polymerization shrinkage leading to gaps formation at the tooth and restoration interface.

A new category of restorative material which is metal-free and offers tooth-colored aesthetics as well as high flexural strength has been introduced. 'Cention N' is an "alkasite" restorative. Alkasite refers to a new category of filling material, which like compomers or ormocer materials is essentially a subgroup of the composite material class. Cention N is a tooth-colored, basic filling material for direct restorations. It is self-curing, radiopaque, and releases fluoride, calcium, and hydroxide ions with optional additional light-curing. As a dual-cured material, it can be used as a full-volume (bulk) replacement material.[9,10]

Cention N is intended for deciduous and permanent teeth restorations of Class I, II, or V nature.[12] Cention N may however be used with or without an adhesive and no etching with phosphoric acid is required when used without an adhesive. Ideally, the present generation of restorative materials in pediatric dentistry should display insignificant or no microleakage for greater success of the restoration.

2. Materials and Methods

This in vitro study was done to evaluate the microleakage properties of restorative materials.

2.1. Microleakage evaluation

Orthodontically extracted 30 premolars free from the crack, caries, and restoration were selected. Teeth were cleaned and stored in distilled water until use. Class I cavity preparations were done with dimensions 1.5 x 2 x 2 mm (l x b x h) of cavity size. The samples were randomly divided into 3 groups of 20 each. The three groups were Group A – Cention-N, Group B - GC Fuji IX, and Group C - Composite Z-350. The teeth were restored with respective restorative materials. They were restored according to the manufacturer's instructions (Table 1). The specimens were kept in a saline solution for 24 hours. The teeth were mounted in the acrylic blocks for good grip.

Fig. 1: Premolar teeth specimens

2.2. Thermocycling and dye penetration

The specimens were subjected to a thermocycling procedure with 500 cycles from 5^0C to 55^0C with an immersion time of the 60s and a well time of 15s. Two coats of nail polish were applied all around the tooth structure leaving a 1 mm window around the cavity margins. Root apices were sealed with acrylic. The samples were immersed in methylene blue

Table 1: Characteristics of selected materials.

Materials		Composition	Manufacturer
GIC (Fuji IX)	Posterior Glass ionomer restorative cement	POWDER: Silica, Alumina, Aluminum Fluoride, Calcium Fluoride, cryolite, aluminum phosphate. Liquid: Polyacrylic acid, Itaconic acid, tartaric acid, maleic acid.	GC America
Composite Z-350	Nano-Filled	Matrix: Bis-GMA, UDMA, Bis-EMA, TEGDMA, PEGDMA. Fillers: nano silica, nano zirconia, nanoclusters (0.6-10 μm) (78.5 wt%)	3M ESPE, Minnesota United States
Cention-N	Arkansite	The liquid comprises dimethacrylate (UDMA, DCP, an aromatic aliphatic UDMA, and PEG-400 DMA) and initiators, whilst the powder contains various glass fillers (barium aluminum silicate glass filler, ytterbium trifluoride, an Isofiller, a calcium barium aluminum fluorosilicate glass filler and a calcium fluorosilicate (alkaline) glass filler, initiator (Ivocerin) and pigments.	Ivoclar Vivadent

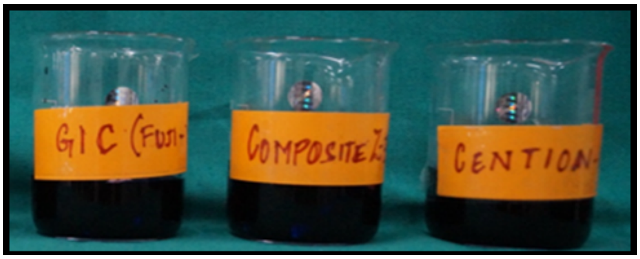

Fig. 2: Samples in dye penetration

for 24 hours and then

thoroughly washed and dried. The samples were sectioned in a buccolingual and occlusal-cervical direction through the middle of the restoration by using a micromotor straight handpiece mounted with a diamond disc. The sectioned samples were evaluated under a stereomicroscope (40x magnification).

2.3. Microscopic examination and scoring

Each prepared section was inspected under a stereomicroscope with a video output device to assess the dye penetration at the margins of the restorations. The microleakage was observed at a magnification of 40X. A computer linked to the Stereomicroscope via an inbuilt camera was used to capture the images. The degree of microleakage of both halves of the sectioned teeth was examined. The section showing the maximum degree of dye penetration was chosen for grading the degree of microleakage. The extent of microleakage was noted proportionate to the penetration of dye between the tooth structure and the restoration & scored using the scoring criteria (Prabhakar et.al 2003) given below:

2.3.1. Scoring criteria

The microleakage evaluation based on the degree of dye penetration was scored via a graded qualitative scale – (Figure 3)

Score 0: No dye penetration.

Score 1: Dye penetration between the restoration & the tooth up to enamel only.

Score 2: Dye penetration between the restoration & the tooth into enamel & dentin

Score 3: Dye penetration between the restoration & cavity floor.

The scores were tabulated; interpreted & resultant findings were statistically analyzed.

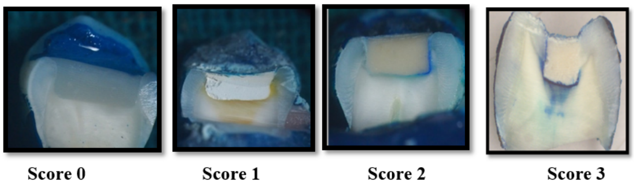

Fig. 3: Microleakage in a cavity preparation

Statistical analysis was done using IBM SPSS version 20. The test applied was Chi-square and Kruskal Wallis tests.

3. Results

The distribution of dye penetration was scored and tabulated in groups I – III. (Table 2). There was a significant difference in the pattern of the dye penetration score. As the result suggest Cention-N has shown the least microleakage as compared to other groups.

4. Discussion

Restorative materials are substances that are used to repair, replace, or enhance the tooth structure. The main cause of failure of restorative materials, is the maximum loss of bonding or adhesiveness to enamel and dentin, leading to microleakage, which is the prime concern in restorative dentistry.[7]

The restorative material should demonstrate adequate strength, adaptability, marginal integrity, and natural color match. The poor marginal seal allows marginal

Table 2: Comparison of dye penetration using chi square test

Dye Penetration	Groups Group I	Group II	Group III	Total
0	0 0.0%	0 0.0%	0 0.0%	2 4.0%
1	5 50.5%	7 70.0%	10 100.0%	
2	5 50.5%	3 30.0%	0 0.0%	
3	0 0.0%	0 0.0%	0 0.0%	
Total	10 100.0%	10 100.0%	10 100.0%	50 100.0%

Chi-square value =35.038, p-value <0.001*

Table 3: Kruskal wallis test comparison of mean dye penetration

	Dye Penetration				
	Mean	Std. Deviation	Mean rank	Critical value	p-value
Group I	1.50	0.53	27.00	8.123	<0.001*
Group II	1.30	0.48	22.40		
Group III	1.00	0.00	15.50		

percolation, with probable bacterial invasion leading to marginal deterioration and marginal staining, postoperative sensitivity, secondary caries, pulpal inflammation, and pulp pathosis.[10]

Cention N (Ivoclar Vivadent) has been recently introduced as a tooth-colored, restorative filling material for bulk placement in retentive preparations with or without the application of an adhesive.[8–18]

As in the present study results achieved, Fuji IX showed more microleakage than composites. The results are supported by Andreina Castro and Robert F. Feigal (2002)[11] who found that cavities filled with new-generation glass ionomer cement (Fuji IXGP^{TM}) had significantly less leakage than with conventional glass ionomer cement in permanent teeth. In comparison with composites, GIC has shown more microleakage than the composites. Diwanji A et al (2014)[12] also compared Fuji IX to other varieties of GICs where, Fuji IX showed the maximum leakage, in class I restorations. There was a significant difference when compared to Fuji LC II and KN 100. They also compared class V restorations, Fuji IX with KN100, KN 100, and LC II which showed significant differences. The study concluded Fuji IX exhibited maximum leakage.[11]

In the present study, similar results were obtained showing the composite Z-350 to be better than GIC Fuji IX. There was a study conducted by Mali P et. al (2006)[13] study which concluded that microleakage was evident in all restorative materials used in the study, but Glass ionomer showed maximum microleakage followed by composite resin. In a study by Somani R et al (2016)[14] they found the least microleakage in Self-cured GIC (Ketac Molar Easy Mix) when compared to Compomer (Dyract), Packable composite (Filtek P60), Resin Modified Glass ionomer cement (GC Fuji II LC), Micro filled composite (Durafill VS) and Nanocomposite (Filtek Z350). Nanocomposite (Filtek Z350) showed maximum microleakage when compared to GICs. According to this study, GICs showed better adhesion than composite Z-350 due to which the microleakage was less in GIC. But in the present study, the results obtained varied, and composites showed less microleakage than GIC Fuji IX.[14]

There was a study conducted by George p and Bhandary S (2018)[15] who used restorative materials such as amalgam, GIC, packable composite, and Cention-N with adhesive and without adhesive, respectively. Their study concluded that Cention-N without adhesive showed the least microleakage compared to GIC and composite restorations, thereby having a better sealing ability. Another study was conducted by Mazumdar. P (2019)[16] found the least microleakage in Cention-N.

In the present study, Cention-N is a better material for Class I restorations than composites and GIC. Hence the study concluded that Cention-N is a newer restorative material that displayed minimum microleakage when compared to GICs. The result obtained from this study proves that the microleakage of GIC (Fuji IX) is highest, followed by, composites and Cention N.

5. Conclusions

Within the limitation of this study and regarding the results, it is concluded that all the restorative systems tested in this study exhibited some amount of microleakage. This was inevitable irrespective of the type of material being used, and the microleakage was lower in Group C- Cention-N compared with Group A- GC FUJI IX and Group B - Composite Z-350. The study concludes that Cention – N can be used as a restorative material.

6. Source of Funding

None.

7. Conflicts of interest

There are no conflicts of interest.

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Cite this article: Iftikhar N, Dixit S, Salman A, Do MT. Comparative evaluation of marginal microleakage of various restorative materials used in pediatric dentistry – An in-vitro stereomicroscopic study. *IP Int J Med Paediatr Oncol* 2023;9(1):1-5.