ORIGINAL RESEARCH

Microleakage Evaluation of an Alkasite Restorative Material: An *In Vitro* Dye Penetration Study

Arjun Kini[1], Shishir Shetty[2], Raksha Bhat[3], Preethesh Shetty[4]

Abstract

Aim: The aim of the present *in vitro* study was to comparatively evaluate the microleakage in three different esthetic restorative materials in class I cavities using the dye penetration technique.

Materials and methods: Class I cavities were prepared on 24 human maxillary premolar teeth. The teeth were randomly divided into four groups of six samples each. Group I: Cention-N without adhesive (Ivoclar Vivadent, India), group II: Cention with adhesive (Ivoclar Vivadent, India), group III: type IX glass ionomer cement (Fuji), group IV: posterior composite (3M ESPE). The specimens were polished, subjected to thermocycling, and suspended in methylene blue dye for 24 hours. The teeth were sectioned longitudinally and the extent of microleakage was evaluated using the stereomicroscope.

Results: The results were subjected to statistical analysis using the Pearson's Chi-square test and the interobserver variability was assessed by the Kappa test for interobserver variability. The analysis showed statistically significant results among the groups. Although, Cention N with adhesive showed the least microleakage followed by Cention N without adhesive.

Conclusion: All the materials tested were unable to completely eliminate microleakage in class I cavities. However, the newer alkasite material Cention N proved to have the least microleakage among all groups.

Clinical significance: According to the present study, Cention N, a newer alkasite restorative material, demonstrated promising results with the least microleakage in comparison with posterior resin composites and glass ionomer cements.

Keywords: Adhesive, Class I cavity preparation, Dental restorations, Microleakage, Resin composites.

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Introduction

Microleakage is one of the primary concerns in modern-day practice as its prevention ensures long-lasting restorations. Microleakage is commonly observed at the margins of the tooth restoration interface, leading to secondary caries and marginal staining. It has also been known to cause pulpal pathology if not treated in time.[1]

Since the dawn of 1970s, dentistry has been revolutionized with the introduction of esthetic, tooth-colored restorative materials to modern-day dental bulk fill composites. Capturing the essence of the strength of amalgam with esthetic restorative materials has been a challenging task, given its characteristic features, which are considered fundamental in the success of restorations.[2] However, a cardinal factor modern-day practice emphasizes upon for the success of restorations is achievement of a good seal with reduced microleakage, often observed with esthetic restorative materials.[3] Thus, the earnestness to combine the strength of the restorative material with an impenetrable seal and low microleakage has invariably lead to the advent of newer esthetic restorative materials.[4]

To overcome drawbacks of the esthetic restorative materials, an alkasite restorative material, Cention N, has been introduced, comprising of an alkaline filler, which releases acid neutralizing ions along with fluorides, calcium, and hydroxide ions when the pH of the oral cavity is low. It is a dual-cure material, with the cross-link polymerization reaction between the monomers, namely, urethane dimethacrylate, tricyclodecane-dimethanol dimethacrylate, and polyethylene glycol 400 dimethacrylate leading to increased strength and longevity of the restoration.

The aim of the present *in vitro* study was to compare the sealing ability of the commonly used restorative materials, Fuji type IX glass ionomer cement, Filtek Z350 XT composite restorative material with the recently introduced Cention N.

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Materials and Methods

Sample Selection Criteria

Twenty-four noncarious, nonfluorosed human maxillary first permanent premolars with intact occlusal surfaces, extracted for orthodontic purposes, were included in the study. The teeth were disinfected according to the OSHA regulations. Ethical approval was obtained from the institutional ethical committee.

Sample Preparation

Class I cavities were prepared on the occlusal surface of the extracted teeth with 0.8 mm width and 1.5 mm depth using a high-speed handpiece with air–water coolant, with a no. 245 bur.

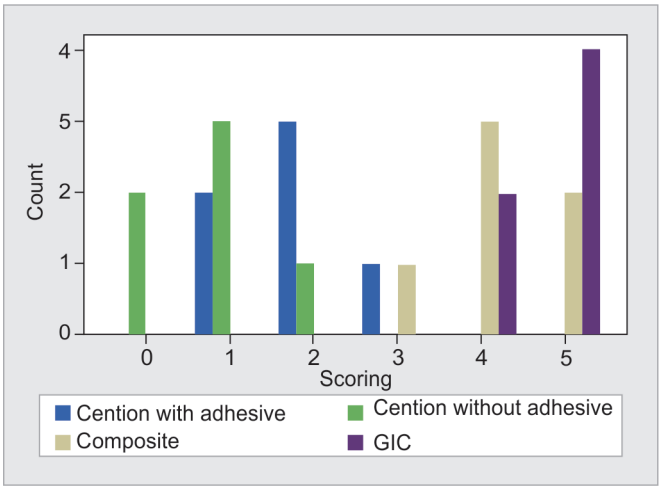

Fig. 1: Comparison of the microleakage among the various groups, as noted by observer 1

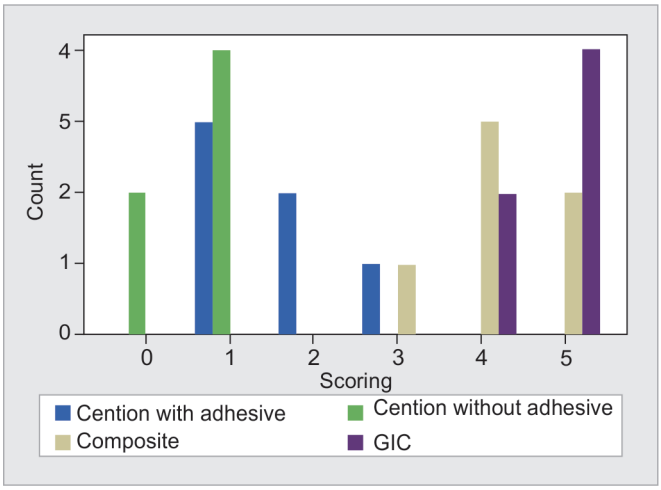

Fig. 2: Comparison of the microleakage among the various groups, as noted by observer 2

William's graduated periodontal probe was used to measure the depth and width of the cavity in order to maintain uniformity of the preparation. One operator prepared all the cavities in order to avoid any discrepancies in the preparation and also to ensure consistent depth and size of cavity preparation.[5]

Restorative Procedure

The teeth were randomly divided into four experimental groups of six teeth in each.

Group I: Cention-N without adhesive (Ivoclar Vivadent, India), group II: Cention with adhesive (Ivoclar Vivadent, India), group III: type IX glass ionomer cement (Fuji), group IV: posterior composite (3M ESPE).

All the prepared cavities were then restored as per manufacturer's instructions.

Group I: It is supplied as powder and liquid. The standard powder to liquid ratio is 1:4.6. The samples were restored by bulk placement and polished.

Group II: Tetric N-Bond Universal (Ivoclar Vivadent, India) was applied and light-cured (Bluephase, Ivoclar Vivadent) for 20 seconds then Cention N was placed in bulk and light-cured for 20 seconds.

Group III: It is supplied as powder and liquid. The standard powder to liquid ratio is 3.6:1. After mixing with a plastic spatula, the material was placed into the cavity using a plastic filling instrument by bulk placement.

Group IV: The composite samples were prepared by the incremental layer technique and polished. All the samples were stored for 24 hours in distilled water.

Thermocycling and Microleakage Evaluation

After the restorations were polished, the specimens were subjected to thermocycling. The teeth were subjected to temperature baths of 5°C, 37°C, and 55°C, with a dwell time of 30 seconds in each bath.[4] Except for 1 mm around the periphery of the restorations, the external surface of all samples was coated with two coats of varnish to seal the radicular part of the tooth. The root apices were then sealed with glass ionomer cement.[6] All the 24 samples were submerged in the 1% aqueous solution of the methylene blue dye for a period 24 hours. The samples were thoroughly washed under distilled water to remove any excess dye that may be present on the material or the tooth surface, which may interfere with accuracy during assessment of dye penetration. The tooth samples were mounted on acrylic blocks up to the cementoenamel junction. The teeth were longitudinally sectioned using a slow-speed diamond disc along the mesiodistal axis. One-millimeter-thick buccolingual sections were made per sample, measured and standardized using a metal gauge. The extent and degree of marginal leakage was further evaluated under a stereomicroscope.

The scoring criteria used to evaluate microleakage are as follows:[7]

0° = no leakage

1° = less than or up to one-half of the depth of the cavity preparation

2° = 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

Khera and Chan's (1978) scoring criteria were used to evaluate the degree of microleakage. Two observers evaluated the microleakage of teeth.

Results

The data obtained were statistically analyzed using the Pearson's Chi-square test and the interobserver variability was assessed by the Kappa test for interobserver variability.

According to the data obtained from observer 1 and observer 2, Cention N with adhesive showed significantly least microleakage in comparison to the other evaluated restorative materials (Figs 1 and 2).

4 + 5 + 2 + 5 + 6 = 22/24 κ value greater than 0.8 is indicative of excellent agreement and is significant with *p* value less than 0.001 (Table 1).

Discussion

An increased demand for esthetic restorative materials has necessitated constant research in the field to develop novel materials that do not compromise the pulp, provide long-lasting esthetically pleasing restorations while also maintaining the seal at the tooth restoration interface. Resin-based technology is one such area with continual developments.[8] Despite the scientific

Table 1: Interobserver variability among the groups

Score by observer 2 × score by observer 1 cross-tabulation								
			Score by observer 1					
			1	*2*	*3*	*4*	*5*	*Total*
Score by observers	1	Count	**4**	0	0	0	0	4
		% within score by observer 2	100.0	0.0	0.0	0.0	0.0	100.0
		% within score by observer 1	80.0	0.0	0.0	0.0	0.0	16.7
	2	Count	1	**5**	0	0	0	6
		% within score by observer 2	16.7	83.3	0.0	0.0	0.0	100.0
		% within score by observer 1	20.0	83.3	0.0	0.0	0.0	25.0
	3	Count	0	1	**2**	0	0	3
		% within score by observer 2	0.0	33.3	66.7	0.0	0.0	100.0
		% within score by observer 1	0.0	16.7	100.0	0.0	0.0	12.5
	4	Count	0	0	0	**5**	0	5
		% within score by observer 2	0.0	0.0	0.0	100.0	0.0	100.0
		% within score by observer 1	0.0	0.0	0.0	100.0	0.0	20.8
	5	Count	0	0	0	0	**6**	6
		% within score by observer 2	0.0	0.0	0.0	0.0	100.0	100.0
		% within score by observer 1	0.0	0.0	0.0	0.0	100.0	25.0
Total		Count	5	6	2	5	6	24
		% within score by observer 2	20.8	25.0	8.3	20.8	25.0	100.0
		% within score by observer 1	100.0	100.0	100.0	100.0	100.0	100.0

advancements in the field of resin restorative materials, one of the commonly noted reasons for clinical failures is microleakage.[9]

The present study investigated the microleakage of Fuji type IX (GC), Filtek Z350 XT (3M ESPE), and Cention N (Ivoclar Vivadent) when used in class I restorations.

In the present study, teeth restored with Cention N after application of adhesive presented with least microleakage, followed by teeth restored with Cention N without adhesive. This could be attributed to the patented isofiller, which acts to relieve the shrinkage stresses that in turn help minimize the shrinkage forces. Also, the ratio of the organic and inorganic contents as well as the composition of the monomers is responsible for the reduced volumetric shrinkage leading to reduced microleakage.[10]

The sixth-generation bonding system is a one-step bonding system, known to achieve a strong bond to enamel and dentin. The adhesive agent used in the present study was Tetric N Bond Universal (Ivoclar Vivadent), a mild etching adhesive containing low levels of acidic monomers with a pH of approximately 2.5–3.0. It's matrix comprised of a combination of monomers of hydrophilic nature such as hydroxyethyl methacrylate, hydrophobic nature such as decandioldimethacrylate, and intermediate nature such as bisGMA. The results of the present study can be attributed to the combination of these properties, which helps bridge the gap between the hydrophilic tooth substrate and the hydrophobic resin restoration, providing an optimum seal that in turn helps prevent microleakage.[11,12]

In the present study, Cention N was compared with Filtek Z350 XT and Fuji type IX glass ionomer cement. Filtek Z350XT, a nanofilled composite, is known for its compressive strength and lesser polymerization shrinkage.[5,6,13–15] However, in the present study, the results demonstrated more microleakage with Filtek Z350XT in comparison to Cention N. In the present study, Fuji IX showed the maximum amount microleakage among all the groups. The results of the present study are in accordance with a study done by Mali et al., which concluded that the conventional glass ionomer cement comparatively exhibited higher microleakage in comparison to resin glass ionomer and composite. The dehydration of the type IX GIC is maintained by the continual outflow of dentinal fluid from freshly cut dentin increasing the wetting of the dentin, thereby enhancing the hydrated gel phase during solidification. This results in internal microcracks, which help maintain the bulk volume. The internal cracks close to repair the cohesive strength, due to the water sorption.[16,17] This helps maintain the dimensional stability of the glass ionomer cement, leading to excellent adaptation to the tooth structure. However, due to *in vitro* conditions in the present study, the dehydration leading to decrease in the cohesive strength might alter the properties of the cement, which would have resulted in leakage.

In the present study, class I cavities were prepared on the teeth considering the "c" factor, i.e., ratio between number of bonded and unbonded surfaces.[18] All the samples were subjected to thermocycling in order to simulate the intraoral conditions.[19] Among the various methods used to detect microleakage, dye penetration with methylene blue has proven to be a time-tested method. Methylene blue (0.5%) was used in the present study due to the low molecular weight of the dye known to be smaller than bacteria, useful to detect leakage in places where even bacteria cannot penetrate.[20]

Microleakage evaluation is preferred to be done with *in vitro* models rather than with *in vivo* methods. These tests can be subdivided into older methods and novel methods. The air pressure technique, the fluid filtration technique, electrochemistry, neutron activation, bacteria, and artificial caries were the former methods used for microleakage evaluation. Over time, these techniques were found to be unable to reproduce the conditions of microleakage and hence have been replaced by novel methods such as the radioisotope method, the acetate peel technique, and dye penetration followed by microscopic evaluation by a stereomicroscope, confocal microscope, and optical coherence

tomography. In the present study, the dye penetration assay was used to evaluate the microleakage as it has various advantages over other techniques as no reactive chemicals or radiation is used. Also, a number of dye solutions are available, making the technique highly feasible and easily reproducible.[21]

Despite the results obtained in the present study, the clinical performance of any material cannot be predicted solely on the basis of the *in vitro* study, even though Cention N exhibited promising results. Hence, *in vivo* studies are a necessity to arrive at a final conclusion of microleakage of the alkasite restorative.

Conclusion

The present study concluded that none of the materials were completely free of microleakage. However, the cavities restored with Cention N following application with an adhesive showed the least microleakage among all groups. Further studies with different cavity preparation designs and contemporary microleakage studies can be done to confirm the same.

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