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ORIGINAL ARTICLE

An in Vitro Study Comparing Nano-Composite Microleakage with and without Hydroxyapatite-Reinforced Glass Ionomer Cement and Cention N as a Base Material in Class I Cavity

ALBADAH AS[1], KHAN AM[2]
[1]*College of Dentistry, Qassim University, Buraydah Saudi Arabia*
[2]*Assistant Professor, Department of Conservative Dental Sciences and Endodontics, College of Dentistry, Qassim University, Buraydah, Saudi Arabia*
Corresponding autor: Asma Munir khan, Email: dr.asma.munir@qudent.org

ABSTRACT

Aim: This study assessed microleakage in class one cavities in premolar teeth treated with Nano-composites using Cention N and Hydroxyapatite reinforced Glass ionomer cement as a base.

Materials and Methods: In Sixty premolars, Class I cavities, one-fourth the intercuspal distance wide and 0.5-1mm deep were formed. Three groups were made. Group 1 received only Nano-Composites, Group 2, Nano-Composites with Cention N, and Group 3, Nano-Composites with Hydroxyapatite reinforced GIC was used as a base material. After 24 hours in distilled water, samples were undergone 5000 thermocycles at 5°C to 55°C. Samples were dried, and apical surfaces were sealed and saved for a 1mm wide zone around the restoration margins. Teeth were coloured with 2% Methylene blue. All the teeth were longitudinally sectioned and examined under a microscope

Results: The least microleakage and internal gaps with GIC reinforced by Hydroxyapatite used as a base material (1.03± 0.832), followed by Nanocomposites. (2.08 ± 1.347). However, the greatest microleakage was observed with Cention N when used as a base (2.60 ± 0.928). A strong positive correlation was also observed between microleakage and internal gap formation.

Conclusion: Cention N demonstrated the maximum microleakage as a base material, followed by Nanocomposite. GIC with Hydroxyapatite as a base material showed the least microleakage.

Keywords: Cention N, GIC reinforced by Hydroxyapatite, Nanocomposite, base material, Microleakage

INTRODUCTION

The restoration of occlusal cavities has been investigated for a long time, depending on the specific clinical scenario and patient requirements. (1) Amalgam has a long usage and therapeutic efficacy history as a direct posterior restorative material. Due to its longevity, low cost, and manufacturability, it remained the preferred material for decades. (2, 3) However, due to the potential risk of mercury toxicity, bioelectric currents in the oral cavity, corrosion, failure to attach to the tooth structure, recurring caries, undesirable dark grey stains on the teeth, and soft tissue, its use has been fundamentally replaced. In addition to the supposed negative effect, its inferior aesthetic look is the greatest downside. This resulted in the creation of several tooth-coloured restorative materials. (4, 5)

Due to the increasing demand for esthetic restorations, dentists worldwide have widely used dental composites. However, these resins have aesthetic, functional and biocompatible advantages over amalgams as restorative materials and can be used in posterior and anterior applications. Composite resin is a feasible alternative to amalgam for posterior restorations since it is non-metallic, mercury-free, electrically and thermally inert, and attaches directly to hard tooth tissues. They are technique-sensitive but provide a superior seal and satisfy the patient's aesthetic requirements. However, their application in a wider cavity remains difficult due to their major problem of polymerization shrinkage, which results in the formation of gaps and consequent microleakage. (6, 7)

The incremental placement technique, the use of low shrinkage composite resins, the soft-start polymerization method, and the placement of base materials such as flowable composites, polyacid-modified resin composites, and an intermediate bonding base material have been advocated as solutions to this problem. Using nano-technology, low-shrinkage composite resins have been produced to boost the durability of restorations. (8, 9) Nanohybrid composites employ a novel nanofiller technique that blends the hybrid's strength with the microfill's aesthetic appeal. The binding strength and mechanical properties of nanohybrid composites are much greater than those of traditional composites. (10) However, polymerization shrinkage remains the most significant disadvantage of resin composites. (11)

Due to its unique qualities such as chemical attachment to the tooth structure, fluoride release, good sealing ability, decreased shrinkage values, and almost acceptable esthetics, conventional Glass ionomer cement (GIC) is regarded as the gold standard for usage in "sandwich technique." (12) However, its primary disadvantage is its susceptibility to moisture, which leads to water absorption and hygroscopic expansion, leading in the creation of cracks, cement deterioration, and microleakage. (13)

In order to address these limitations, hydroxyapatite-reinforced GIC cements were introduced recently. The hydroxyapatite nanoparticles have been incorporated with GIC to increase its fluoride ion release, compressive strength, and antibacterial activity. (14) In addition, Cention N, a new type of metal-free filling material with tooth-colored aesthetics and superior flexural strength, has been released. Cention N is a restorative substance that belongs to the subgroup of composite resins known as "Alkasites" and is used as a direct restorative material. (15, 16) Microleakage measurement is the most significant test parameter for determining the success and durability of any restoration. Dimensional variations or a failure of adaptation of the filling material may result in microleakage. (16) This microleakage may cause change of color around the margins, penetration of the microorganisms, develeopment of secondary carious lesions, eventually resulting in the failure of the restoration. Furthurmore, microleakage may also irritate the dental pulp. (17)

This study's objective was to investigate Microleakage in Nanocomposites with or without the use of hydroxyapatite-reinforced Glass ionomer cement and Cention N as a base material in an in-vitro study.

MATERIALS AND METHODS

In the Department of Conservative Dentistry and Endodontics, College of Dentistry, Qassim University, a comparative in vitro study was undertaken. The Research Ethical Committee approved the study (No. EA/F-2019-3011). Sixty intact, freshly extracted, non-caries permanent human premolar teeth were used. The study excluded teeth having caries, root resorption, fracture lines, and cracks. The extracted teeth were kept in distilled water until the start of the experiment. The teeth were cleaned using an ultrasonic scaler. Class I cavities were created without bevels using a high-speed handpiece with a width of roughly one-fourth of the intercuspal distance and a depth of 0.5-1mm below the dentino-enamel junction. To confirm regularity in cavity size William's graduated probe was used to evaluate the cavity depth. Cavities were then extensively cleaned with phosphoric acid gel (cica) containing 35% phosphoric acid for 15 seconds to remove debris and smear layer, washed with water spray for 10 seconds, and air-dried. A bonding agent (3M AdperTM) was used, followed by 20 seconds of light-curing (Densply, QHL75). Premolars were then randomly categorized into three groups of 20 based on the following criteria:

Group 1: The Nano-hybrid composite (Tetric N-Ceram) was applied using an oblique incremental approach, and each layer was cured for 20 seconds. However, the last coat was cured for 40 seconds. Under the composite, a single bond universal adhesive (3 M ESPE) was applied and cured for 15 seconds.

Group 2 – Nano-composites with Cention N (as a Base); Cention® N was prepared as instructed, applied to a 1mm base, and cured for 40 seconds. Afterwards, the insertion of Nano-hybrid composite followed the application of bonding substance.

Group 3 – Nano-composite with Hydroxyapatite-Reinforced GIC (as the Base): A 1 mm thick layer of self-curing Micron Bioactive Hydroxyapatite Modified-Glass Ionomer Cement was mixed per the manufacturer's instructions and applied. Two measuring scoops of powder and two to three drops of Liquid were combined to create a putty-like consistency. Then, bonding material was applied, followed by the Nano-hybrid composite.

To simulate the clinical condition and to eliminate inter-examiner error, all preparations and restorations were performed by a single operator. Additionally, a double-blind sampling method was applied. The operator colour-coded all samples so that neither the lab technician nor the score reader could determine the material used. Afterwards, the restorations were completed and polished using diamond burs and soflex discs.

After restoration, the samples were held for 24 hours in distilled water at 37 degrees Celsius. To simulate the oral cavity, samples were treated to 5000 cycles of thermocycling in the range of 5°C and 55°C water baths with a 20-second rest duration in each bath. After thermocycling, the samples were dried, and the apices of the teeth and all surfaces were coated with acrylic, except for a 1mm wide zone surrounding the margins of each restoration. The teeth were then put in 2% Methylene blue dye for 24 hours. After that, they were put in water for five minutes

Using a slow-speed, water-cooled diamond disc, the samples were longitudinally sectioned in the mesio-distal direction, congruent with the restoration's center. The two parts of each tooth that exhibited dye penetration were selected and analyzed using a digital microscope (HIROX KH-7700) at magnifications ranging from 1X to 7000X (field of view from 340mm to 0.049mm). A total of 40 longitudinal sections were analyzed. The maximum degree of dye penetration was measured based on the following scoring criteria (ISO/TS 11405-2003): **(Table 1).** (18)

Table 1: Testing of adhesion to tooth structure criteria

Score	Testing of adhesion to tooth structure criteria
0	No dye penetration
1	Dye penetration into the enamel part of the cavity wall
2	Dye penetration into the dentin part of the cavity wall but not including the pulpal floor of the cavity
3	Dye penetration including the pulpal floor of the cavity

To ensure process standardization, a single lab worker performed all laboratory operations. The statistical analysis was conducted using SPSS 21.

RESULTS

In Nano-Composite (Control Group) mean microleakage score was found to be 2.08±1.347 (P= 0.086). However, for the Cention group, it was 2.60± 0.928 (P =0.086), and for Hydroxyapatite reinforced GIC mean value calculated was 1.03±0.832 (P<0.05). A P-value less than 0.05 was considered as statistically significant. **(Table 2)**

Table 2: Mean Microleakage score and standard deviation between different groups

Groups	N	Mean	Std. Deviation	P value	F Anova
Nano Composite(Group1)	40	2.08	1.347	0.086	22.915
Cention N (Group 2)	40	2.60	.928	0.086	
Hydroxyapatite Reinforced GIC (Group 3)	40	1.03	.832	<0.001*	

Table 3 displays the inter-group comparison of the frequency distribution of various microleakage scores by using the Chi-Square Test. The three groups had a significantly different number of sample units in different categories with respect to depth of penetration as seen in the Frequency distribution graph [Graph 1] (P < 0.05).

Overall, the maximum sample unit 61 (50.83%) showed a microleakage score of 3, most of which belonged to Group 2. Maximum sample units showed scores 0 in Group 1, score 1 in Group 3, score 2 in group 2, and score 3 in group 3, respectively.

Table 3: Inter-group comparison of the frequency distribution of various microleakage scores

	score 0	score 1	score 2	score 3	Chi -Square Value	P- value
Nano Composite	11 (28%)	1 (3%)	2 (5%)	26 (65%)	71.513	<0.0001*
Cention N	4 (10%)	0 (0%)	4 (10%)	32 (80%)		
GIC Reinforced hydroxyapatite	9 (23%)	26 (65%)	2 (5%)	3 (8%)		

DISCUSSION

Microleakage is a common problem with dental fillings. Microleakage measurement is the most important parameter for determining any restoration's success and long-term effectiveness. (16) Microleakage can result in marginal discolouration, postoperative sensitivity, bacterial infiltration, secondary caries, restorative failure, and pulpal irritation. (19) It may not cause immediate damage or symptoms but could lead to consequences in the near future if not remedied on time.

The incremental placement technique, the use of low shrinkage composite resins, the soft-start polymerization method, and the placement of base materials such as flowable composites, polyacid-modified resin composites, and an intermediate bonding base material have been advocated as solutions to this problem. (6, 7, 20)

In the current in vitro investigation, Class I cavities were made and filled with imitating clinical conditions characterized by maximum polymerization shrinkage, resulting in microleakage with composites due to a high C-factor. To simulate the oral cavity, each sample was treated with 5000 cycles of thermocycling between 5°C and 55°C water baths.(21)

In the present investigation, microleakage was measured by scoring procedures outlined in ISO/TS 11405-2003 in order to identify the maximum degree of dye penetration. In addition, 2 percent of Methylene blue dye was utilized. "ISO 11405:2003 Scoring techniques provide information on substrate selection, storage, and handling and the basic aspects of several test procedures for evaluating the integrity of the adhesive connection between restorative dental materials and tooth structure, i.e. enamel and dentine. It defines two tests for measuring bond strength (tensile and shear), a test for measuring marginal gaps around fillings, and a microleakage test and providing recommendations for clinical usage tests for such materials. It also provides particular test procedures for measuring bond strength ". (18)

Moorer and Kersten discovered that the most frequently employed leakage dye was methylene blue, whose molecular size is comparable to that of a tiny bacterial metabolic product with a corresponding molecular size. Methylene blue is a dye with low molecular weight and great penetrability.(22)

The base material with the greatest microleakage (dye penetration) was Cention N, followed by bulk filled Nano Composite. GIC reinforced by hydroxyapatite group, when employed as a base, exhibited the lowest microleakage (dye penetration). In contrast to prior research, where Cention N depicted the least microleakage, the present study demonstrated the highest microleakage (dye penetration) with Cention N when utilized as the base material. (23, 24) This can be attributed to the fact that Cention N was used as a bulk fill and direct restorative material in earlier studies. As per our knowledge, no studies were done before using Cention N as a base material.

GIC reinforced by Hydroxyapatite was associated with the lowest microleakage. Hence, it was more dependable than the other two materials and fitted exceptionally well to the tooth structure. It displayed superior performance as compared to the other two materials when used to restore class I cavities. Moreover, the use of GIC reinforced with Hydroxyapatite has been recommended by prior research. (15) Incorporating various weight percents of nano-hydroxyapatite powder (HA) into GIC cement increases fluoride ion release and improves the material's compressive strength and antibacterial characteristics.

Since the current investigation is lab-based, with a limited sample size, future in- Vivo studies are recommended to substantiate these results. In forthcoming studies, along with higher sample size, important clinical parameters such as restorative strength, durability, and marginal adaptability must be evaluated.

CONCLUSION

Cention N used as base material showed the maximum microleakage followed by Nanocomposite when used as a direct restorative material. However, GIC reinforced by Hydroxyapatite used as a base material is the most promising material as it depicted the least microleakage.

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