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MICROLEAKAGE OF CLASS II RESTORATION: AN IN VITRO STUDY

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Abstract

Microleakage is one of the features of interest to clinicians because it directly affects the durability of restoration. Alkasite is a new basic restoration material, formed on the basis of resin Composite combined with alkaline fillers. The purpose of this study was to compare the microleakage between three groups of filling: Alkasite, Composite and glass ionomer cement (GIC).

1. Background

Currently, the main concerns regarding the performance of dental materials are their durability and the integrity of marginal sealing. Clinically, one of the most important problems of restorative dentistry is the failure of restorative materials to completely bond to enamel and dentin, which causes microleakage. Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between tooth and the restorative material [1]. The appearance of microleakage leads to marginal opening, pulpal irritation, postoperative sensitivity, marginal staining and secondary caries [2].

Until now, direct fillings have made great strides, stemming from the aesthetic needs and durability of restoration as well as the impact on dental tissue.

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Key words: microleakage, Alkasite, Composite, GIC

Composite is now considered to be a clinically-selected material because of its good aesthetic properties and can help to reinforce hardness of the remaining tooth tissue thanks to the bond system. However, the contraction due to polymerization affects the adhesive force between the tooth tissue and the material, thereby forming microleakage. Glass ionomer cement (GIC) materials show the advantages of bonding with tooth structure, ease to use and most importantly releasing of fluoride [3]. However, a number of studies have still recorded gaps in teeth restored by GIC, along with lack of sufficient strength and toughness [3-7].

For a long time, researchers have been looking for a new restoration material, which is a product that is able to release fluoride, cost-effective, fast and easy to use without complicated equipment, high strength and good aesthetics. Cention N is a new restoration material, made of resin composite combined with alkaline fillers, providing the above characteristics plus other advantages compared to both Amalgam and GIC [5].

Currently, there are not many studies on microleakage of class II Alkasite restorations. The studies of George P. and Bhandary S. (2018) concluded that Cention N proved to be superior in terms of integrity of marginal sealing when compared to composite and Fuji IX [3]. However, the study of Punathil S. (2019) showed that the Resin Modified Glass Ionomer Cement (RMGIC) group exhibited the least microleakage, followed by the Cention N group and the Nanocomposite group showing the largest microleakage [8]. Therefore, we conducted research on the subject of "Microleakage of class II restoration: an in vitro study" with the objective of comparing the degree of microleakage between Alkasite restoration with Composite and Glass Ionomer Cement restorations.

2. Materials and Methods

The sample consisted of 30 premolars extracted for orthodontic purposes.

Inclusion criteria

- Intact crown, no decay, no old restorations, mature tooth with apical closure of roots.

- Guaranteed tooth size: occlusal-gingival dimension $\geq 5mm$; buccal-lingual dimension $\geq 4mm$.

Exclusion criteria Cracked teeth, dysplasia, fluorosis.

Method The sample consisted of 30 premolars with class II (3mm in the direction of occlusal-gingival, 2mm in the mesial-distal, 2mm in the buccal-lingual) prepared by diamond burs coded SF-12, TC-11 EF, FO-20EF (Mani, Belgium), numbered from 1-30 and randomly divided into 3 groups:

- Group 1 (10 teeth): restored with Alkasite Cention N (Ivoclar Vivadent, Switzerland).
- Group 2 (10 teeth): restored with Composite Tetric N-Ceram (Vivadent, Switzerland).
- Group 3 (10 teeth): restored with GIC Fuji IX (GC, Japan).

After restoration according to the manufacturer's, the teeth were immersed in physiological saline solution for 24 hours, after that the teeth underwent 100 thermocycles between temperature baths at 5oC and 55oC, the dwell time at each thermal point is 25 seconds, conversion time is 5 seconds. Next, the specimens were isolated by covering the tip of roots by wax and applying two layers of nail polish varnish to the entire tooth surface, excluding 1mm around the margin restoration. Then, the teeth were soaked in 2% methylene blue solution for 24 hours. After being soaked, the specimens were cleaned and sectioned longitudinally through the middle of the restoration with diamond cutting discs and then polishing with sandpaper.

The degree of microleakage was observed and assessed in 3 times on the cross section by the degree of penetration of the dye into the gingival wall with semi-quantitative method: assessed through digital microscope with magnification of 60 times by ImageJ.exe software on a scale of George P. and Bhandary S. (2018).

Evaluate the penetration level of dye solution by semi-quantitative method on a scale of George P. and Bhandary S. (2018) [3].

+ Degree 0: no dye penetration;
+ Degree 1: up to 1/2 the gingival seat;
+ Degree 2: > 1/2 the gingival seat;
+ Degree 3: all along the gingival seat;
+ Degree 4: degree 3 plus into the axial wall.

Analyzing data

- Use SPSS 20.0 software to enter data, management and processing.
- Algorithms used:

+ Calculating the average value and standard deviation of the measured values.
+ Comparing 2 independent groups by Mann-Whitney U test, the test was used with 95% confidence.

4. Results

Chart 1. The proportion of teeth appearing microleakage in the Alkasite, Composite, GIC groups are 50%, 80% and 100%, respectively.

The distribution of degree of microleakage in 3 groups are shown in table 1:

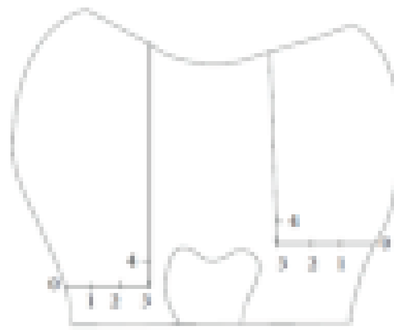

Fig 1. Scoring criteria for dye penetration [3]

Fig 2. Microleakage score of teeth in the study
with a scale of George P. and Bhandary S. (2018).

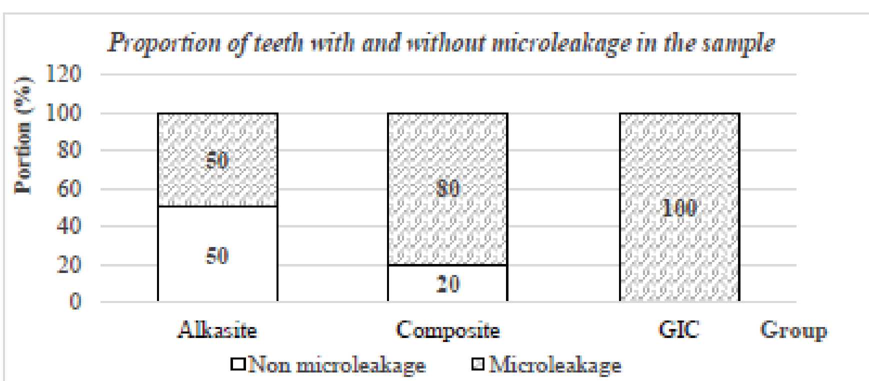

Table 1. Distribution of degree of microleakage in 3 groups.

Group / Degree	Alkasite		Composite		GIC	
	n	%	n	%	n	%
0	5	50	2	20	0	0
1	5	50	6	60	4	40
2	0	0	1	10	2	20
3	0	0	0	0	0	0
4	0	0	1	10	4	40

Table 2. Compare the degree of microleakage between Alkasite and Composite group.

Group	n	Mean ± Standard deviation	P value
Alkasite	10	0,50 ± 0,53	$p > 0,05$
Composite	10	1,20 ± 1,14	

Table 3. Compare the degree of microleakage between Alkasite and GIC group.

Group	n	Mean ± Standard deviation	P value
Alkasite	10	0,50 ± 0,53	$p < 0,05$
GIC	10	2,40 ± 1,43	

- In Alkasite group, 50% of the teeth has degree of microleakage 0 and 50% of the teeth has degree of microleakage 1, no teeth has degree of microleakage of 2, 3 and 4.

- In Composite group, 20% of teeth has degree of microleakage 0, 60% of teeth has degree of microleakage 1, the number of teeth with degree of microleakage 2 and 4 are accounting for 10%, no teeth has degree of microleakage of 3.

- In GIC group, the number of teeth with degree of microleakage 1 and 4 are accounting for 40%, 20% of the teeth has degree of microleakage of 2; none of the teeth has degree of microleakage 0 and 3.

Chart 2 shows: Mean degree of microleakage of 3 groups are 0.50 ± 0.53 in Alkasite group; 1.20 1.14 in Composite group; 2.40 ± 1.43 in GIC group.

Result from table 2: Mean degree of microleakage of Alkasite group is 0.50 and the Composite group is 1.20 with $p > 0.05$.

Table 3 demonstrates that: Mean degree of microleakage of Alkasite group is 0.50 and the GIC group is 2,40 with $p > 0.05$.

4. Discussion

Results from chart 1 show no restoration material is completely optimal when it comes to the level of fitting with the dental tissue.

4.1 Compare the degree of microleakage between Alkasite and Composite group.

The research results from table 2 show the average degree of microleakage of the Alkasite material group is 0.50 and that of the Composite group is 1.20 with $p > 0.05$. Thus, Alkasite restoration has less microleakage than Composite restoration. However this difference is not statistically significant.

There are some similarities in the composition of the two materials. In terms of filler, both materials have basic fillers such as Barium glass, Ytterbium trifluoride, Isofiller (which reduces the force of contraction). Besides, the content of inorganic fillers in volume of Cention N accounts for 57.6%, approximately the content of inorganic fillers in Teric N-Ceram is 55 - 57%. The content of filler is one of the factors influencing polymerization shrinkage. The space occupied by the fillers does not participate in the polymerization shrinkage [4]. The similarity of the filler content between Cention N and Teric N-Ceram leads to the volume of polymerization shrinkage is not much different.

However, our research results are not consistent with the results of the authors George P. and Bhandary S. (2018) when comparing microleakage among the Amalgam, GIC Fuji IX, Composite, Cention N materials with the results Cention N group provides less microleakage than Composite group [3]. The reason for this difference is that George P. and Bhandary S. used Packable Composite (a type of high-strength Composite, used for the posterior tooth, which is the size fillers range from 0.04 - 20 μm) while the Composite type used in our study is Teric N-Ceram, a Nanohybrid Composite with fillers size of 0.04 - 3 m, smaller than the fillers size in Packable Composite. Materials with smaller fillers will allow a reduction in polymer shrinkage, thus exhibiting a lower degree of microleakage than a material with larger fillers [9].

Cention N includes a special patented filler (partially functionalized by silanes) which keeps shrinkage stress to a minimum. This Isofiller acts as a shrinkage stress reliever which minimizes shrinkage force, whereas the organic/inorganic ratio as well as the monomer composition of the material, is responsible for the low volumetric shrinkage [10]. When the material polymerises, either in self-cure modus or via additional light-curing, the monomer chains located on the fillers together with the silanes begin a cross-linking process and forces between the individual fillers come into play which (if the restorative has been placed adhesively) place stress on the cavity walls. This stress is influenced by both volumetric shrinkage and the modulus of elasticity of the material. A high modulus of elasticity denotes inelasticity and a low modulus of elasticity denotes higher elasticity. Due to its low elastic modulus (10 GPa) the shrinkage stress reliever within Cention N acts like a spring (expanding slightly as the forces between the fillers grow during polymerization) amongst the standard glass fillers which have a higher elastic modulus of 71 GPa [10].

There are many factors leading to the ability of Composite to form microleakage. One cause of microleakage for Composite materials is due to the decrease in volume during rapid polymerization of Dimethacrylates, creating stresses that are recognized as important factors affecting edge integrity of Composite materials and can lead to breakage of links between materials and surrounding tooth structure [11]. In addition, the coefficient of thermal expansion of Composite is (25 - 60 ppmoC), which is several times higher than that of enamel (11.4 ppmoC) and dentin (8 ppmoC). This physical property is considered to increase the harmful effects of polymerization shrinkage [6]. On the other hand, during the light-cure process, air oxygen inhibits the polymerization of the surface layer, forming a gel-like surface - also known as the oxygen-inhibited layer (OIL), has been suggested to inhibit polymerization and contribute to lowering the degree of conversion. The presence of OIL has a detrimental effect on integrity of marginal sealing [12].

4.2. Compare the degree of microleakage between Alkasite and Glass Ionomer Cement group.

According to the results from table 3: the average microleakage of Alkasite group is 0.50 and the GIC group is 2.40 with the p ¡ 0.05, indicating that

Alkasite results in a lower microleakage, compared to GIC and the difference is statistically significant. This result is similar to the results of George P. and Bhandary S. (2018) [3]. The similarities as reflected in this study of the results of this study is because the studies compare microleakage on the same material groups as Cention N and GIC Fuji IX, the classes are all made with diamond bur and the steps for restoration are the same.

However, our results are inconsistent with the results of Punathil S. Research of Punathil S. (2019) when assessing the microleakage on class II with the Ketac N100 (RMGIC), Z350 (Nanocomposite resin) and Cention N materials have shown that Cention N has a larger gap than RMGIC and less than Nanocomposite Resin [8]. The reason for this discrepancy is that Punathil S. used RMGIC, different from the material used in our research: GIC Fuji IX. RMGIC has the same main components as conventional GICs (glass powder, water, polyacid and added monomer and the corresponding initiation system. RMGIC bonding is a process of combining two correlated reactions including: mechanical micro-locking thanks to GIC self-etch process with polyacid component; and the true chemical bonds are ionic bonds formed between carboxylate groups of polyacid molecules and calcium ions on the tooth surface [13]. Thus, compared with GIC Fuji IX, RMGIC is more advantageous has more advantage in bonding to tooth tissue. This helps reduce the possibility of microleakage formation with the teeth restored by RMGIC.

Many studies show that the failure of GIC restoration usually starts in the heart of the material, not the bond interface [14]. The cohesive strength of GIC is found to be lower than adhesive strength. The porous nature of the material may be an important factor that enhances potential for microleakage [15]. GIC bonds chemically to tooth achieved via initial cross linking of Ca ions with polyacrylic acid forming calcium polyacrylate chains. Final setting involves cross linking of trivalent Al ions with polyacrylic acid forming aluminium polyacrylate chains. The Ca and Al polyacrylate cross linked chains become hydrated over time with water being present in the liquid. This process is known as maturation. Thus, the microstructure of set cement consists of agglomerates of unreacted glass particles (glass cores which serves as filler in cement matrix) surrounded by silica gel embedded in an amorphous matrix of hydrated Ca and Al polysalts. Water plays an important role in setting reaction of GIC by serving initially as reaction medium and then slowly hydrates the matrix. During initial setting, water is loosely bonded to Ca polyacrylate chains and at this stage, any loss of water from exposure to ambient air or uptake of water from moisture contamination results in chalky, cracked surface and leaching of ions from matrix respectively. Both uptake and loss of water results in weak and more soluble cement with reduced translucency. Hence, this is prevented by coating of varnish immediately after placing the restoration [6]. There are several nominally-suitabale barrier materials, solvent-based or polymerizing varnished that are sufficiently durable impervious to water, although none is yet ideal. The most effective may be something like a light-cured bonding resin [16].

5. Conclusion

Alkasite and Composite have similar efficacy in preventing microleakage. Alkasite represents the lower microleakage than GIC. The difference was statistically significant. Conflict of Interest: No potential conflict of interest relevant to this article was reported.

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