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^{99m}Tc in the evaluation of microleakage of composite resin restorations with SonicFill^{TM}. *In vitro* study.

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ABSTRACT

Introduction: The composite SonicFill^{TM} (Kerr/Kavo) recently introduced in the market is indicated for posterior restorations, with a single increment up to 5mm due to reduced polymerization shrinkage, thus reducing working time.

Aim: Evaluation of marginal microleakage with SonicFill^{TM}.

Method and materials: In this in vitro experimental study, were sectioned thirty noncarious human molars in occluso-cervical direction. Class V cavities were prepared on the buccal or lingual surfaces of each tooth with gingival margin walls in enamel and dimensions: 4 mm mesiodistally, 3 mm occlusogingivally and 3 mm depth. The specimens were divided in 4 groups: group 1 - restored with SonicFill^{TM} (Kerr/Kavo), group 2 - restored with Filtek^{TM} Supreme XTE (3M ESPE), group 3 – the cavities were not restored; group 4 – restored with SonicFill^{TM} (Kerr/Kavo). In groups 1, 2 and 4 the enamel is conditioned with 37% orthophosphoric acid and applied the self-etch adhesive system Clearfil^{TM} SE BOND (Kuraray). The specimens were stored in distilled water at 37ºC for 7 days. Followed thermocycling: 500 cycles between 5ºC and 55ºC with a dwell time of 30 seconds. After immersed for 3 hours in a solution of ^{99m}Tc-Pertechnetate the radioactivity was assessed with a gamma camera. The nonparametric Kruskal-Wallis and Mann-Whitney test with Bonferroni correction at a significance level of 5% were used for the statistical analyses.

Results: There are significative differences between the positive and negative control groups and between these and experimental groups ($p < 0.05$). There are no statistically significant differences between the specimens restored with SonicFill^{TM} and Filtek^{TM} Supreme XTE.

Conclusion: The new composite SonicFill^{TM} and Filtek^{TM} Supreme XTE didn’t show difference concern to the dye penetration. The SonicFill^{TM} restorative system doesn’t show influence in what concerns to microleakage.

Keywords: Posterior resin composites; Composite restorations; Polymerization stress; Polymerization shrinkage; Microleakage; Thermocycling.

INTRODUCTION

Amalgam was for years the most used restorative material by dentists. Due to aesthetic reasons, environmental and questionable biocompatibility of alloys that contain mercury, practitioners needed to seek a new material that would satisfy these needs. The resin composites, introduced in the 1960s[1,2], satisfied aesthetic needs, and nowadays they represent a class of materials widely used in restorative dentistry.[3]

The resin composites should present a lot of basic requirements: good optical characteristics, the physical properties should correspond with those of dental hard tissue, wear resistance, distinguishable from dental tissue on x-ray, easy to handle and polish, be tasteless and biocompatible and should form a sufficient bond with dental tissue or at least with the dental adhesive.[4] However, many clinical and material limitations have restricted the universal use of resin composites as posterior restorative material.[1]

Despite having good physical properties, the main shortcomings of composite resin materials are polymerization shrinkage[1,2,3,5,6,7,8] and polymerization stress[5]. Shrinkage stress resulting in internal microcracks within the bulk of the material[7]; separation of the bonding agent from the cavity wall with resultant gap formation, marginal microleakage and post-operative sensitivity[1,3,7,8,9]; enamel microcracks[5,7]; marginal staining[8]; wear[9]; discoloration[9]; lower fracture resistance[1,5,9]; recurrent caries[1,3,8,9]; and deformation of tooth[5,7].

Microleakage is the clinically undetectable passage of bacteria, fluids, molecules and ions between the cavity wall and the restorative material[1,10,11] and is considered to be a major factor influencing the longevity of dental restorations.[1] The decrease of the polymerization shrinkage and consequent decrease of microleakage, can be obtained by oblique layering technique with increments or design cavities with a low C-factor.[1,6] On the other hand, some changes in restorative materials, made in the past, like improvements in the filler technology and formulation of composite materials, improved performance of the resins.[8,9,12]

A novel resin composite system, SonicFill™ System (Kerr/Kavo), was recently introduced in the market. Is indicated for use as a bulk fill posterior composite restorations and can be bulk filled in layers up to 5mm in depth due to reduced polymerization shrinkage.[13] SonicFill™ incorporates a highly-filled proprietary resin with special modifiers that react to sonic energy.[13] As sonic energy is applied through the handpiece, the modifier causes the viscosity to drop (up to 87 %), increasing the flowability of the composite enabling quick placement and precise adaptation to the cavity walls. When the sonic energy is stopped, the composite returns to a more viscous, non-slumping state that is perfect for carving and contouring.[13]

One of the objective methods for microleakage rating is the use of radioactive isotopes.[14] Technetium is an artificial element, obtained by the radioactive decay *molibdenium,* which is a radioactive metallic element belonging to the transition metals with atomic radius 135.8pm. It's the element 43 of the periodic table, and the radioactive element with a lower atomic number. This presents a half-life of 2.6 hours. Its decay occurs by the isometric transition and emission and 140.5 keV of gama radiation.[14]

The purpose of the present study is to evaluate the microleakage of the dental restorations with SonicFill™ (Kerr/Kavo). The null hypothesis is that the type restorative system doesn't have influence in what concerns to microleakage.

METHOD AND MATERIALS

Thirty noncarious extracted human molars were hand scaled and stored in normal saline solution 0,9% (B. Braun, 11496403, Queluz de Baixo, Barcarena) at 5ºC no more than 4 months after extraction. The teeth were cut with a saw Exakt System 300 (Exakt System, Norderstedt, Germany) in two equal halves occlusogingivally. Class V cavities were prepared on the buccal or lingual surfaces of each tooth. The cavity dimensions had approximately 4 mm mesiodistally, 3 mm occlusogingivally and 3 mm of depth. An internal line angle of 90 degrees was maintained to create occlusal and gingival margins walls of approximately 4 mm. Both margins were located in enamel. A transparent resin mold was performed to design the cavities in each tooth surface (Figure 1). The burs FG 835/010 (Proclinic, 34/09, Nyon, Swiss) were replaced after every 5 preparations.

The specimens were divided randomly in each group. Forty specimens were used for the study group and twenty specimens for each control group.

Group 1: a SonicFill™ (Kerr/Kavo, 3691651, Bismarckring, Biberach) activated, bulk fill composite shade (A2) was used to restore the class V cavities of 20 specimens. The enamel was conditioned during 30 seconds with 37% phosphoric acid gel Octacid Jumbo™ (Clarben, T012RD, Lindigo, Sweden), washed right after with an air/water jet during 30 seconds (Figure 2). A self-etch bond agent, Clearfil™ SE BOND (Kuraray, 041872, Okayama, Japan) was used according to fabricant instructions (Figure 3). Clearfil™ SE BOND primer was applied to enamel/dentin using scrubbing motion and left for 20 seconds, dried thoroughly with mild air flow, Clearfil™ SE BOND bond was applied to enamel/dentin surface using light brushing motion, dried with air flow gently and light cured during 10 seconds using light cure BluePhase™ G2 (Figure 4). The SonicFill™ was placed in one bulk increment followed by shaping the buccal surface and light cured for 20 seconds using light cure BluePhase™ G2 (Ivoclar Vivadent, 5VDC, Liechtenstein, Austria) (Figure 5). Restorations were polished using Sof-Lex Disk System (Brown/Orange/Light Orange/Yellow, 3M ESPE, N301289, St. Paul, MN, USA).

Table I. Materials used in the study.

Material	Lot no.	Manufacture
SonicFill System	3691651	Kerr/Kavo
Filtek Supreme XTE	N339166	3M ESPE
Clearfil SE BOND	O41872	Kuraray

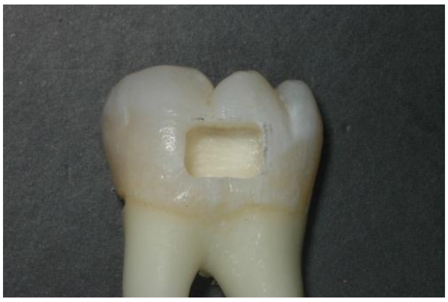

Figure 1. Cavity preparation to receive the resin composite.

Figure 2. Enamel conditioning with 37% phosphoric acid for 30 seconds.

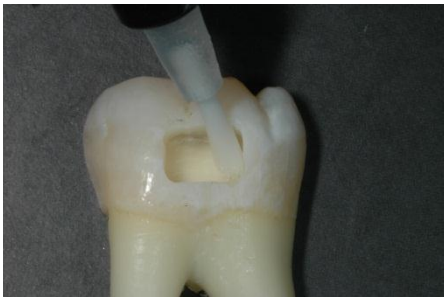

Figure 3. Application (2 steps) of a self-etch adhesive system.

Figure 4. Polymerization of each component.

Figure 5. Composite SonicFill™ System.

Figure 6. Composite Filtek™ Supreme XTE.

Group 2: a Filtek^{TM} Supreme XTE (3M ESPE, N339166, St. Paul, MN, USA) shade A2 was used to restore the class V cavities of 20 specimens. The enamel was conditioned during 30 seconds with 37% phosphoric acid gel Octacid Jumbo™ (Clarben, T012RD, Lindigo, Sweden), washed right after with an air/water jet during 30 seconds (Figure 2). A self-etch bond agent, Clearfil^{TM} SE BOND (Kuraray, 041872, Okayama, Japan) was used according to fabricant instructions (Figure 3). Clearfil^{TM} SE BOND primer was applied to enamel/dentin using scrubbing motion and left for 20 seconds, dried thoroughly with mild air flow, Clearfil^{TM} SE BOND bond was applied to enamel/dentin surface using light brushing motion, dried with air flow gently and light cured during 10 seconds using light cure BluePhase™ G2 (Figure 4). The Filtek^{TM} Supreme XTE was placed in two increments followed by shaping the buccal surface and light cured for 20 seconds using light cure BluePhase™ G2 (Ivoclar Vivadent, 5VDC, Liechtenstein, Austria) (Figure 6). Restorations were polished using Sof-Lex Disk System (Brown/Orange/Light Orange/Yellow, 3M ESPE, N301289, St. Paul, MN, USA).

Group 3: the class V cavities of 10 specimens weren’t restored.

Group 4: a SonicFill^{TM} (Kerr/Kavo, 3691651, Bismarckring, Biberach) activated, bulk fill composite shade (A2) was used to restore the class V cavities of 10 specimens. The enamel was conditioned during 30 seconds with 37% phosphoric acid gel Octacid Jumbo™ (Clarben, T012RD, Lindigo, Sweden), washed right after with an air/water jet during 30 seconds (Figure 2). A self-etch bond agent, Clearfil^{TM} SE BOND (Kuraray, 041872, Okayama, Japan) was used according to fabricant instructions (Figure 3). Clearfil^{TM} SE BOND primer was applied to enamel/dentin using scrubbing motion and left for 20 seconds, dried thoroughly with mild air flow, Clearfil^{TM} SE BOND bond was applied to enamel/dentin surface using light brushing motion, dried with air flow gently and light cured during 10 seconds using light cure BluePhase™ G2 (Figure 4). The SonicFill™ was placed in one bulk increment followed by shaping the buccal surface and light cured for 20 seconds using light cure BluePhase™ G2 (Ivoclar Vivadent, 5VDC, Liechtenstein, Austria) (Figure 5). Restorations were polished using Sof-Lex Disk System (Brown/Orange/Light Orange/Yellow, 3M ESPE, N301289, St. Paul, MN, USA).

The same operator performed all restorative procedures. The specimens were stored in distilled water at 37ºC for one week and then went through thermocycling 500 cycles between 5ºC and 55ºC with a dwell time of 30 seconds, and no further treatment. The specimens of groups 1, 2 and 3 were covered with two layers of red nail varnish (Resist and Shine L’Oréal, 16G901, Paris, France) until 2 mm of margins around the restorations (Figure 7, 8 and 9). The specimens of the group 4 were covered all over its surface (Figure 10). The specimens of all groups were immersed in ^{99m}Tc-Pertechnetate solution during 3 hours

Figure 11). Afterward the varnish was removed. The radioactivity issued by the specimens was detected by the gamma camera. The statistical analysis was performed using the program SPSS 19. Comparisons were made using the nonparametric Kruskal-Wallis test and multiple comparisons were made using the Mann-Whitney test with Bonferroni correction. A significance level of 5% was considered.

Figure 7. Specimens of group 1 covered with two layers of red nail varnish.

Figure 8. Specimens of group 2 covered with two layers of red nail varnish.

Figure 9. Specimens of group 3 covered with two layers of red nail varnish.

Figure 10. Specimens of group 4 covered with two layers of red nail varnish.

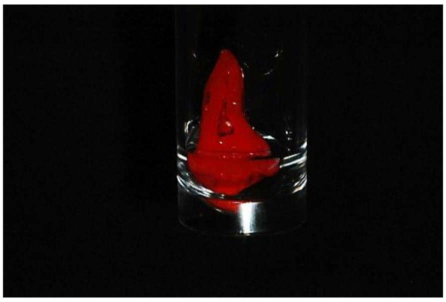

Figure 11. Immersion in ^{99m}Tc-Pertechnetate solution during 3 hours.

RESULTS

In this study, 60 specimens were used, assigned to group 1 (n = 20), group 2 (n = 20) and positive (n = 10) and negative (n = 10) control groups. After acquiring the values of the average counts of each tooth, multiple group comparison were performed using the nonparametric Kruskal-Wallis test, since, although there was a normal distribution of the values obtained, there wasn't the homogeneity of variances necessary to apply the ANOVA test. Mann-Whitney test with Bonferroni correction was used to calculate p value among different test group. We established the level of Statistical Significance at $p<0.05$. If $p<0.05$, it Indicates significant difference. If $p<0.001$, it Indicates highly significant difference among groups.

Data analysis showed that there was statistically significant differences between experimental groups and control groups ($p<0.05$) in accordance with that shown in Table II. Apart from these differences, highly significant difference was observed between negative and positive control groups ($p<0.001$), as shown in Table II. In the positive control group there was a large microleakage, and the negative control group received minimum counts, as shown in Table III and Figure 12.

Table II. Statistical comparison according to the Mann-Whitney test with Bonferroni correction.

Grupos	p
G1/G2	1.000
G1/G3	0.005
G1/G4	0.004
G2/G3	0.001
G2/G4	0.015
G3/G4	<0.001

Table III. Means and standard deviation of the microleakage in the experimental and control groups.

Grupos	Média ± DP
G1	0.08±0.04
G2	0.07±0.02
G3	0.35±0.14
G4	0.03±0.01

Regarding the comparison of scores obtained by groups 1 and 2, according to the Table II, a significative statistical difference was not observed ($p >0.05$). However, there is a greater tendency to infiltration by the SonicFill™ compared with Filtek™ Supreme XTE, as we can see in Table III and Figure 12.

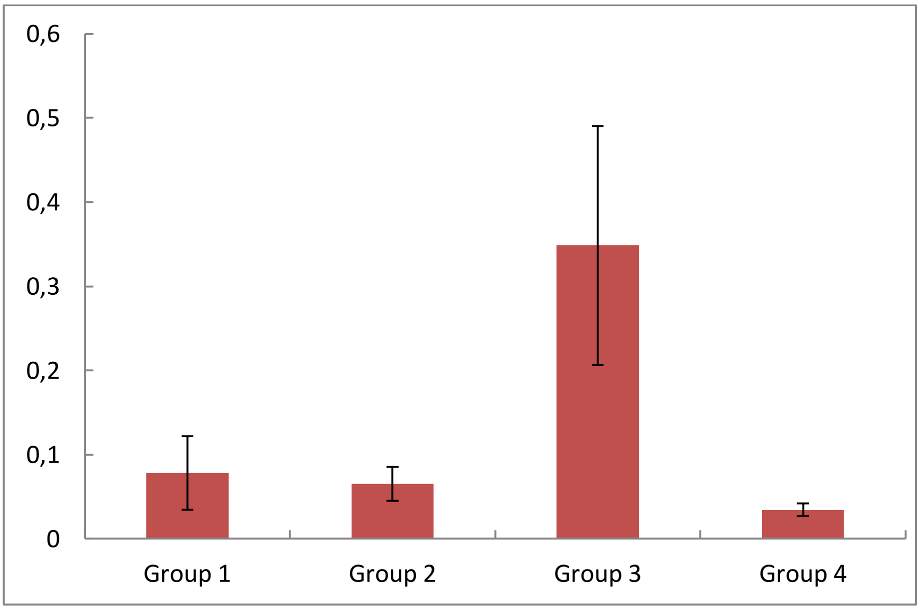

Figure 12. Marginal microleakage in the 4 groups.

DISCUSSION

Aesthetic considerations are playing a greater role in the treatment planning of dental care, even in the restoration of posterior teeth, stimulated by the popularity of aesthetics, patient demands for nonmetallic restorations and the controversy about the systemic and environmental effects of dental amalgama. Those facts have stimulated the development of adhesive dentistry.

Resin composites can be used for different purposes such as: restore the function and esthetics of dental hard tissue lost due to caries or trauma, correct malposition/malocclusion or gaps, repair restorations, build up fractured teeth and create stump build-ups for prosthetic reconstruction, cement indirect restorations, bond orthodontic appliances and seal fissures.[15]

They are a combination of inorganic particles, organic resinous matrix and coupling agents. The inorganic particles are made of quartz, ceramic and silica[4] and they provide material strengthening and reinforcement[3]. Divers types, shapes, sizes, volume fractions, and distributions of filler particles affect the material's properties, such as hardness, thermal stability, radiopacity, gloss retention and roughness, water sorption, viscoelastic creep and recovery, fracture toughness, fracture behavior, elastic moduli.[3] Properties like water sorption, the linear expansion coefficient and polymerization shrinkage decreased with increase filler content, whereas, the compressive and tensile strength, the modulus of elasticity and wear resistance rises with increasing filler content.[4] The resin matrix consists of organic monomers, photo initiators, co-initiators, inhibitors of polymerization, UV-stabilizers and small amounts of additional components that vary according the manufacturer.[3] The monomer, that is in larger amounts, in the resin matrix is Bis-GMA (bisphenol-A-glycidyldimethacrylate).[3,4] This monomer makes the resin viscosity very high, so it's mixed in different combinations with short-chain monomers such as TEGDMA (triethylenglycol-dimethacrylate).[3,4] However, as negative effects, the addition of TEGDMA to the resin formulation increase the water sorption[3] and polymerization shrinkage[3,4]. Furthermore, increase the tensile but reduces the flexural strength of the resin.[4] There are others monomers that have also been used and tested.[3] The coupling agents are used to bond the inorganic filler with the organic matrix, since these don't have chemical affinity. The common agent is y-MPTS (y-methacryloxypropyl-triethoxysilane.[3] Silanisation of the filler is important for material strength.[4]

The integrity of the marginal seal is essential to increase the longevity of the restoration.[16] That integrity is compromised when microleakage occurs resulting from polymerization shrinkage. As previously mentioned, polymerization shrinkage is the most common cause of failure of direct posterior composite restorations. The polymerization shrinkage is a very complex phenomenon dependent upon the boundary conditions, the amount of material the polymerization reaction and the material's formulation.[3] This phenomenon occurs because monomer molecules are converted into a polymer network and, therefore, exchange Van der Walls spaces into covalent bond spaces, creating contraction stresses in the resin composite leading to microleakage.[1] It's divided into two phases: the pre-gel-polymerization, in which the composite is able to flow and stress within the structure is relieved and after gelation flows ceases and cannot compensate the stress; the post-gel polymerization, results in significant stress in the surrounding tooth structure and composite-tooth bond.[6]

Different resin composites have different formulations and consequently different polymerization shrinkage. Many studies have suggested the use of incremental layering technique to reduce this shrinkage.[1,3,17] Nowadays, traditional placement techniques for composite resins include this technique.[3] Most practitioners recommended placing composites in 2 mm increments. However, every dentist who places posterior composite resins wish a composite material that can be used using a bulk fill technique similar to that of dental amalgam.

In this study we used two resin composites: a conventional one, Filtek™ Supreme XTE, and a bulk fill activated system, SonicFill™ System. Filtek™ Supreme XTE is a nanocomposite that contains nanometric particles and nanoclusters, and presents high translucency, high polish and polishes retention similar to microfilled composites and physical properties and wear resistance equivalent to several hybrid composites.[18] SonicFill™ System was introduced in the dental market in 2010 and it combines the properties of a flowable composite with those of a universal composite: oscillation energy temporally increases flowability of the composite to achieve precise filling of cavities. An advantage of this composite is the rapid placement through a single increment up to 5mm due to reduced polymerization shrinkage, thereby reducing working time.[13]

The aim of this study was to evaluate the microleakage of the dental restorations with SonicFill™, compared with a universal composite.

Thirty noncarious extracted human molars were selected. Despite all the teeth are molar present differences in respect of its length, diameter and anatomy. However, with the random division of the teeth of the four groups was expected to obtain a fair comparison between the different groups. Class V cavities were prepared on the buccal or lingual surfaces of each tooth with cavity dimensions approximately 4 mm mesiodistally, 3 mm occlusogingivally and 3 mm depth.[19]

The success of composite restorations depends on the adhesion of restorative materials to hard tooth tissue. The dental adhesives have different tooth-composite interface morphologists, different bond strengths and different abilities in microleakage prevention.[20] To promote adhesion of the composite to enamel and dentin was chosen a two-step self-etch adhesive, Clearfil™ SE BOND. Self-etch adhesive systems promotes the dissolution of the inorganic phase of dentin using acidic monomer, with simultaneous infiltration of adhesive monomer around the collagen network that results in fewer exposed collagen fibrils[21]. According Yuasa et al. these adhesive systems have the advantage of saving time, reducing procedural errors and their lower etching ability, decreasing the potential for iatrogenic damage to dental hard tissue.[22] De Goes et al. advocate that Clearfil™ SE BOND presents significantly higher bond strengths than other self-etching adhesives.[23] The enamel was etched previously with 37% phosphoric acid gel, increasing the bond strengths significantly.[24]

Posteriorly, cavities in group 1 and group 4 were restored with a single increment of SonicFill™, as recommended by the manufacture; and cavities in group 3 were restored with Filtek™ Supreme XTE using the incremental technique, recommended by several authors.[3,25,26] According to Schneider et al.[3], Park et al.[25] and Lee et al.[26] the use of an incremental filling technique reduce the cuspal deflection resultant from polymerization shrinkage. Nevertheless the literature is not conclusive concerning the advantages promoted by the incremental technique. Versluis et al.[27] and Loguercio et al.[28] argue that the incremental filling technique produce higher polymerization stresses at the restoration interface compared with bulk fill. In this study it was found that the polymerization shrinkage is similar in both methods, since there was no statistically significant difference as regards microleakage with SonicFill™ and Filtek™ Supreme XTE.

The same operator performed all restorative procedures, to reduce human error operator, like some authors recommended.[10,18,19,31] The specimens were stored in distilled water at 37ºC for one week[2,14] and after thermocycling 500 cycles between 5ºC and 55ºC with a dwell time of 30 seconds.[10,22,29,30] Composite restorations are exposed to various influences in the oral cavity, and therefore to evaluate the microleakage are required methods to reproduce these features. Storage in water is the most common artificial ageing technique, as mentioned Amaral et al. and Yuasa et al..[21,22] Another widely used method is thermocycling.[11,22,31] For Geerts et al. thermocycling is the only in vitro test for stimulating thermal stress in teeth.[32] Thermocycling, according Helvatjoglu- Antoniades et al., simulates the introduction of hot and cold extremes in the oral cavity and shows the relationship of the linear coefficient of thermal expansion between tooth tissues and restorative materials.[6] For Souza et al. thermocycling is a combination of hydrolytic and thermal degradation that simulates the temperature of the oral cavity through sudden changes in temperature.[33] The thermocycling regimens vary between studies with respect to the number of cycles, temperature and dwell time. The International Organization for Standardization (ISO) TR 11450 standard (1994) indicates that a thermocycling regimen comprising 500 cycles in water between 5ºC and 55ºC.[10,22,29,30] However, some authors report that this number of cycles is probably too low to achieve a realistic ageing effect.[21,22]

In order to prevent the infiltration of the isotope, two coats of nail varnish were placed on the surface of the tooth until 2 mm of margins around the restorations, except in the group 4 that the entire surface was sealed.[1] The negative control in this experiment was intended to evaluate the reliability of the varnish, with regard to sealing, the latter has been proven by low scores in this group. Before reading on gamma camera the varnish was removed, which influenced loss of tooth structure upon removal.

There are several methods by which microleakage can be studied such as the use of dyes, chemical tracers, radioactive isotopes, artificial caries, scanning electron microscopy, neutron activation analysis, and electrical conductivity.[11] In this study was used radionuclide ^{99m}Tc due to the fact that this is the most widely used radionuclide in the field of nuclear medicine, such as radionuclide, to select the most cold kits used in the field of nuclear medicine for single photon emission, in addition to its half-decay to be approximately 6 hours was used.[14,34] The immersion time of the teeth in the solution of sodium pertechnetate was determined for 3 hours in order to have time to the foregoing procedures to measure the radiation by gamma camera. The samples were carefully prepared for quantification by gamma camera after the immersion to prevent possible contamination after the immersion time. A gamma camera provided accurate radioactivity results in each sample.

The analyses of the results show that there statistically significant differences between the control groups and study groups ($p < 0.05$), showing that they were effective.

Both composite materials tested presented microleakage. In this study there was no statistically significant difference ($p > 0.05$) between the study groups. However, the group 1 shows more tendency for microleakage.

Between negative and positive control group were found highly significant difference ($p < 0.001$). The negative control group presented the lowest values, while positive control group showed the highest values.

CONCLUSIONS

Within the limitations of this study, it can be concluded that:

- The SonicFill™ and the Filtek™ Supreme XTE do not differ in what regard to microleakage.
- The SonicFill™ System only has the advantage of better clinical handling, reducing labor time.
- Using the radioisotope ^{99m}Tc as a marker of infiltration is simple, quick and objective a quantitative method in the evaluation of microleakage.

Long-term clinical studies need to be carried out to substantiate the results of this study.

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