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EVALUATION OF THE EFFECT OF DIFFERENT CAVITY CONFIGURATION (C-FACTOR) ON MARGINAL ADAPTATION OF LOW SHRINKAGE RESIN COMPOSITES: AN IN VITRO STUDY

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ABSTRACT

The aim of the study was to evaluate the effect of different cavity configuration (C-factor) on marginal adaptation of low shrinkage resin composites. A total of 90 freshly extracted human non-carious premolar teeth was used and divided randomly according to tested materials into two main equal groups (45 each); Silorane based resin composite and kalore resin composite. Each group was subdivided according to the cavity configuration into three equal subgroups of (15 each); flat tooth surface, class II cavity and class V cavity. Each division was divided according to storage time into three subdivisions (5 each); one month, three months and six months. After storage time and dye immersion in silver nitrate 50% wt. for 12 hours. Each tooth was split longitudinally into 2 halves and inspected under stereomicroscope to evaluate the marginal leakage of tooth restoration interface. Finally, a randomly representative specimen from each group was investigated under Scanning Electron Microscope (SEM) to evaluate the qualitative examination. The results of this study revealed that less microleakage of Silorane than kalore. All resin materials when used with the corresponding adhesive system with all C-factors do not completely eliminate the microleakage. There was significant difference between flat tooth surface and both of class II and class V. Silorane and Kalore showed high leakage score at six months storage time.

Keywords: Cavity Configuration, Marginal Adaptation, and Low Shrinkage Resin Composites.

INTRODUCTION

Resin composites were introduced as aesthetic materials for anterior restorations and their use was quickly extended to posterior teeth. Despite the evolution of composite resins and the improvement of the adhesive systems, composite restorations still present some drawbacks. One of the major drawbacks is polymerization shrinkage, which consequently leads to the generation of polymerization stress that may causing debonding between tooth structure and resin composite leading to marginal discoloration and secondary caries that can reduce the longevity of the restoration(1).

Moreover, these stresses may transfer into the tooth structure and can cause micro-fractures and cusp movement. Many efforts have been made in order to reduce the volumetric shrinkage of composite resins, one of them is the chemical formulation of some materials such as; a new class of ring opening monomers of Silorane resin composite. This new type of monomer is obtained from the reaction of oxirane and siloxane molecules(2), the silorane composite polymerizes by a cationic process, which is insensitive to oxygen in contrast to methacrylate (3). Also the Dupont Kalore has a unique property of DX511 monomer (modified urethane dimethacrylate) which reduces shrinkage through its relatively high molecular weight. This new monomer consists of a long rigid core with flexible side arms and a lower number of double bonds make it low shrinkable composite. Among the adverse clinical consequences of the

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polymerization shrinkage are tooth/cavity deformation, cuspal deflection, failure at the composite-cavity interface and microleakage [(4)].

Microleakage is one of the most frequent problems associated with resin composites. Lack of sealing allows the occurrence of marginal gap at tooth restoration interface. The microleakage is the passage of bacteria, fluids or molecules between a cavity wall and the restorative material applied to it, so gap maybe formed at the tooth restoration interface. Polymerization stresses are generated within the restoration and at the margins, and if these stresses exceed the bond strength microleakage may occur at the tooth restoration interface [(5).] Factors that influence stress formation includes; volumetric polymerization shrinkage, elastic modulus and flow of the resin composite, adherence of the resin composite to the cavity walls and the configuration factor of the restoration [(6)].

Cavity configuration factor (C-factor) is the ratio of the bonded surface area in a cavity to the unbonded surface area. The increase in C-factor is associated with progressive weakening of the bond strength. Therefore, the strength of the adhesive interaction with tooth structure should be able to counteract the generated polymerization stresses in the resin composite and at the interface. Otherwise, there can be a deleterious effect on marginal integrity and gap formation [(7)].

MATERIALS AND METHODS

Materials used: Two different restorative materials were used in this study are listed in table (1)

TABLE (1): Brand name, Composition, and Manufacture of the material used:

Product name	Category	Composition	Manufacturer and Batch number
Filtek (P90) Silorane shade A3	Low shrinkable restorative micro-hybrid resin composite	5-15%3,4epoxycyclohexylethylcyclo-polymethylsiloxane; 5–15%bis-3,4-epoxy-cyclohexylethylphenylmethylsilane; 50–70% silanizedquartz;10–20%yttrium-fluoride; camphorquinone	3M ESPE Dental Product St. Paul, MN,USA (3MESPE,website www.3mespe.com) (468933)
Silorane adhesive System (two steps)	Self-etch primer	15–25% 2-hydroxyethyl methacrylate (HEMA)*,15–25% bisphenol a diglycidyl ether dimethacrylate (BIS-GMA), 10 15% water, 10–15% ethanol, 5–15% phosphoric acid–methacryloxy hexylesters, 8–12% silane treated silica, 5–10% 1,6-hexanediol dimethacrylate, 5% copolymer of acrylic and itaconic acid, 5% (dimethylamino) ethyl methacrylate, 3% camphorquinone and 3% phosphine oxide	3M ESPE Dental Product St. Paul, MN,USA (466373)(3MESPE,website www.3mespe.com)
	Adhesive – Bond	70–80% substituted dimethacrylate, 5–10% silane treated silica, 5–10% triethylene glycol dimethacrylate (TEGDMA), phosphoric acid methacryloxy–hexylesters, 3% dl-camphorquinone, 3% 1,6 hexanediol dimethacrylate	3M ESPE Dental Product St. Paul, MN,USA (456311) (3MESPE,website www.3mespe.com)
Kalore ShadeA3	Nano-hybrid composite	Urethane dimethacrylate(UDMA)+ 18%, DX-511 co-monomer Dimethacrylate,Fillers (Fluoro-aluminosilicate glass), Prepolymerized filler, Silicon dioxide, photo initiator, Pigment	GC, Tokyo Japan (1010091) website www.gc-dental.com
G-aenial (One step)	Self etch adhesive	4-Methacryloxyethyltrimllitate anhydride 5-10%, acetone 30-40%, water 15-20% , Dimethacrylat 15-20% , phosphoric acid ester monomer 15-20% , silicon dioxide 1-5% , photoinitiator	GC, Tokyo Japan (12101121) Website www.gc-dental.com

2. Methods;

1. Teeth selection and Grouping;

A total of 90 freshly extracted human non-carious premolar teeth for orthodontic reason without any cracks or fractures were used. The selected teeth 90 were divided randomly into two equal main groups according to the tested low shrinkage resins composite (Silorane based resin composite(S) and kalore resin composite (K)). Each main group was divided into three equal subgroups according to the cavity configuration (15 teeth each) subgroup I; flat dentin (C1), subgroup II; class II cavity (C3) and subgroup; class V cavity (C5). Each division was divided into three subdivisions according to storage time; one month (T1), 3 months (T3) and 6months (T6).

2. Preparation of specimens for different cavity configuration:

C1 factor (C1); (one bonded surface) A standardized flat tooth surface was prepared in 30 teeth (15 for Silorane group and 15 for Kalore group) using carbide burs* in high-speed handpiece with profuse water-coolant by creating a depth cut grooves of 2mm at the occlusal surface of premolar. A graduated periodontal probe was used to confirm the depth. These grooves were united together to create a flat tooth surface (the bur was replaced after 3 preparations).

C3 factor (C3); (3 bonded surfaces) A standardized Class II MOD cavity without any axial step prepared in 30 teeth (15 for Silorane group and 15 for Kalore group) by using carbide burs** in high-speed handpiece with profuse water-coolant. Bucco-lingual width occlusally (2mm) in the middle 1/3 rd of the cusp tip of the teeth. The buccal and lingual walls were approximately parallel. The cavity depth was 2 mm. Burs were discarded after three preparations to maintain cutting efficiency and using graduated periodontal probes to confirm the dimensions.

C5 factor (C5); (5 bonded surface) Standardized class V cavities were prepared on buccal surface of 30 teeth (15 for Silorane group and 15 for Kalore group). The outline of each preparation was prepared by using window matrix give class V shape. The dimensions of class V cavities were 2 mm mesio-distally, 2 mm depth and 2 mm occluso-gingivally with the gingival margin at least 1.0 mm above the CEJ. The preparation was done by using carbide burs*** in high-speed handpiece with profuse water-coolant were used to carry out all preparations. A new bur was used for every three cavity preparations to maintain cutting efficiency and using graduated periodontal probes to confirm the dimensions.

3. Restorative procedures:

Each type of resin composite as well as its corresponding adhesive system was achieved according to the manufacturers' instructions.

A. Application of adhesive system for Filtek P90 resin composite;

Self etching primer of Filtek P90 was firstly applied to 30 teeth in each C-factor group (15 teeth). It was applied to the walls of the entire cavity preparations with a micro-brush and left for 15 seconds, oil free air dried for 5 seconds and then light cured for 10 seconds with halogen light curing system.**** Then adhesive agent was applied with a new micro-brush and left for 10 seconds to allow evaporation of solvent and deeply penetration of the adhesive,

* - #245SC carbide burs, Brasseler, Savannah, GA, USA.
** - #703 carbide burs, Brasseler, Savannah, GA, USA.
*** - #257, SS White, Great White Series, Lakewood, NJ, USA.
****- HelioluxII, Vivadent, Austria,1100-1200 mW/cm2

and then it was gently air dried and cured for 10 seconds.

Application of adhesive system for Kalore resin composite; The bonding procedures was done by using G-aenial self etch adhesive system which applied to the entire walls of the preparations with a micro-brush and lifted for 10 seconds, to allow evaporation of acetone solvent and deeply penetration of the adhesive followed by drying 5 sec and light cured for 10 sec.

Application of resin composite; After adhesive application the restorative material of all groups was applied by incremental technique and light cured for 40 sec. The polymerizing light was calibrated after curing of each group and verified periodically to ensure constancy of light output power according to the manufacturer's instructions, A3 shade color was used for each restorative material, and resin composite was packed by using Teflon applicator into the prepared cavity as the following;

Flat tooth surface (C1); 1mm increment of resin composite was applied on all the tooth surface and light cured for 20 sec and another layer of 1mm was applied and cured for 20 sec.

Class II (C3); the first 2mm increment of resin composite was applied to the buccal wall of MOD cavity obliquely from the pulpal floor to the outer occlusal margins and light cured for 40 seconds. The second increment 2mm was applied to the lingual wall obliquely from the pulpal floor to the occlusal margin and light cured for 40 sec. The remaining of the cavity was filled with 1 mm increment up to the occlusal margin and cured for 40 seconds.

Class V (C5); the first increment 1mm of resin composite was applied diagonally to the occlusal wall of class V cavity and light cured for 20 seconds. Then, the second layer 1mm was applied diagonally to the cervical wall and light cured for 20 seconds. The remaining of the cavity was filled with 1mm and light cured for 20 seconds.

4-Storage of specimens

After restorative procedures the teeth were stored in water at 37°C in an incubator with 100% humidity at different storage time (one day, three months and six months) until they were tested. Through the period of storage time the specimens were thermocycled between 5 °C and 55 °C for 100 cycles (one minute for each).

5-Test methods:

A. Sealing of teeth:

At the end of each aging period, the teeth were removed from the water and dried with oil free air. Then a small soft brush was used to coat the crown and the root of each tooth with clear nail varnish except for the restoration away one millimeter all around the margins of the cavity, the nail varnish was left to dry completely. Additionally, a second layer of varnish was applied to ensure complete sealing of all other surfaces of the tested specimens and lifted to dry.

B. Microleakage measurement using dye penetration technique;

For Stereomicroscope and Scanning Electron Microscope (SEM) examination the specimens were immersed in an aqueous solution of 50wt% ammoniacal silver nitrate (pH 9.5) for 24 h, followed by 8h in a photo-developing solution, to permit the reduction of di-ammine silver ions to metallic silver grains. The specimens were removed from the photo-developing solution and washed in running water for 2min. Then the specimens were dehydrated in ascending concentrations of ethanol as follows: 25% for 20 min, 50% for 20 min, 75% for 20 min, 95% for 30 min, and 100% for 60 min.

C. Sectioning of specimens:

Teeth were sectioned longitudinally in bucco-lingual direction through the middle of the restoration for class V and flat dentin specimens with water coolant using a fin diamond disc at low speed. While for class II MOD specimens the sectioning was in mesio-distal direction through the middle of the restoration.

Microscopic examination and microleakage assessment (quantitative examination):

Both halves for each tooth were examined under stereomicroscope at X 25 magnification. The extent of dye at the tooth restoration interface for all specimens in each group were evaluated. The degree of dye penetration was assessed by using a modified scoring system [20] according to the following criteria

Score 0 = No dye penetration

Score I = Dye penetration along enamel wall only.

Score 2= Dye penetration along enamel and extend up to1mm in dentinal wall.

Score 3= Dye penetration along enamel and extend 2mm in dentinal wall for flat tooth surface and for class II, while extend along the entire length of the cervical floor of class V.

Score 4= Dye penetration up to the dentin bridge more than 2mm in dentinal wall for flat dentin and class II, while extend along the entire length of the cervical floor and one-half of the axial wall of class V.

Scanning electron microscope examination (SEM) (qualitative assessment):

One representative specimen from each group (randomly selected) were used for SEM analysis. Specimens were mounted on a 12 mm metal SEM stub using cyanoacrylate adhesive to examine the tooth- restoration interface. The cut surfaces in each half were ground and polished to high gloss with wet silicon carbide sandpaper of successively 600, 1200, and 4000 grit abrasive to avoid deterioration of electron beam of scanning electron microscope. The surfaces were then sputter-coated with gold (EMS-76M; Earnest) and evaluated under SEM at different magnifications. Photographs were taken and stored digitally.

A. Sputter coating; The specimens were fixed with silver adhesive on the specimen's holder of scanning electron microscope and sputter coated with a thin film of gold 300A° under vacuum to render the specimens surface electrically conductivity.

B. Scanning of the specimen; The holder with the specimen in place was mounted in scanning microscope.* The surfaces of specimens were examined under scanning electron microscope at 7 KV. Photomicrographs were taken at magnifications X1500 to demonstrate the tooth/restoration interface

Statistical analysis: were done using Kruskal–Wallis test followed by Mann–Whitney U test to compare between the different variables. The significance level was set at ($P \leq 0.05$).

There was significant difference between Silorane and Kalore resin composite in all C-factor. Where in flat dentin (C1) the mean leakage value (0.53±0.07) for Silorane was higher than the mean leakage value (0.36±0.05) for Kalore where p-value= (0.001). While in Class II (C3) and Class V (C5) the mean leakage value (1.52±0.7) and (1.95±0.7) respectively for Silorane was lower than the mean leakage value (1.74±0.9) and (2.12±0.1) respectively for Kalore where p-value= (0.001).

RESULTS

1 - Effect of the restorative material types on microleakage (table 2):

A - In C1 (Flat tooth surface) groups: There was significant difference between Silorane and Kalore resin composite in all storage time.

JSM-5500 LV; JEOL Ltd – Japan.

Where at one month and at 3months; the mean leakage score value of Kalore was higher than of Silorane. At 6months; the mean leakage score value (2.10±0.7) of Kalore was equal to the mean leakage score value (0.88±0.06) of Silorane specimens with significant difference between them where p-value = (0.02).

B- In C3 (Class II) groups: At one month and at 3months; There was no significant difference between Silorane and Kalore resin composite. **At 6months;** the mean leakage score value (2.25±0.7) of Kalore specimens was higher than the mean leakage score value (1.85±0.3) of Silorane specimens value with significant difference between them where p-value = (0.01).

C - In C5 (Class V) groups: There was no significant difference between Silorane and Kalore resin composite at all storage time.

TABLE (2): The mean leakage score, standard deviation (SD) and p-values of non-Fluoridated Silorane and Kalore resin composite under the effect of C-factors at different storage times;

C-factor	Restorative materials Storage time	S Silorane Mean ± SD	K Kalore Mean ± SD
C1 Flat dentin	T1	0.00±0.00	0.45±0.06
	p-value	0.01	
	T3	0.50±0.07	1.45±0.8
	p-value	0.03	
	T6	0.88±0.06	2.10±0.7
	p-value	0.02	
C3 Class II	T1	1.05±0.9	0.90±0.07
	p-value	0.2	
	T3	1.55±0.1	1.95±0.8
	p-value	0.04	
	T6	1.85±0.3	2.25±0.7
	p-value	0.01	
C5 Class V	T1	1.45±0.3	1.55±0.05
	p-value	0.1	
	T3	1.84±0.09	2.19±0.7
	p-value	0.3	
	T6	2.10±0.7	2.40±0.8
	p-value	0.4	

2- Effect of Configuration factor on microleakage (figures 1):

There was significant difference between Silorane and Kalore resin composite in all C-factor. Where in flat dentin (C1) the mean leakage value (0.53±0.07) for Silorane was higher than the mean leakage value (0.36±0.05) for Kalore where p-value= (0.001). While in Class II (C3) and Class V (C5) the mean leakage value (1.52±0.7) and (1.95±0.7) respectively for Silorane was lower than the mean leakage value (1.74±0.9) and (2.12±0.1) respectively for Kalore where p-value= (0.001).

3-Effect of storage time on microleakage figures (2); There was no significant difference between the mean leakage value (0.90±0.09) of Silorane at one month and (0.92±0.09) of Kalore at one month where p-value (0.2). Also at three months no significant difference between the Silorane and Kalore. While a statistically significant difference was found between the mean leakage value (1.70±0.6) of Silorane at six months and the mean leakage value (1.83±0.6) of Kalore at six months where p-value (0.04).

Scanning Electron Microscope observations: -

Scanning Electron Microscope (SEM) was used to determine the marginal gap and it can provide a more accurate picture of the marginal leakage.

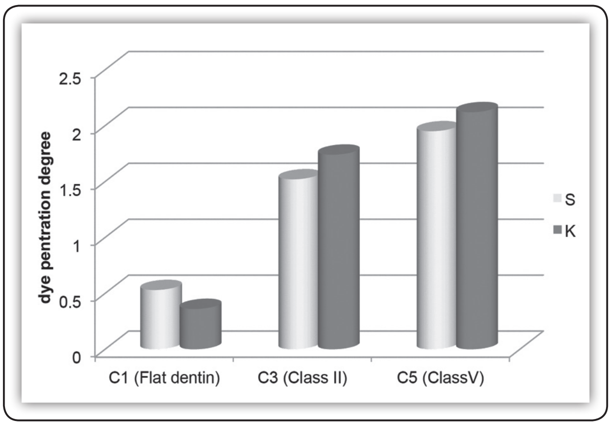

Fig. (1): Bar chart representing of the effect of C-factor for restorative material

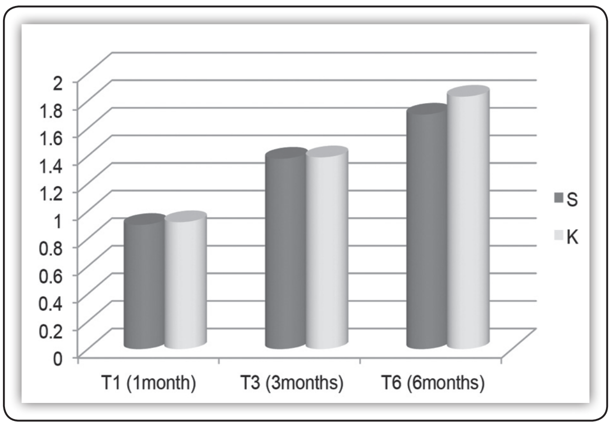

Fig. (2): Bar chart representing the effect of storage time on restorative materials

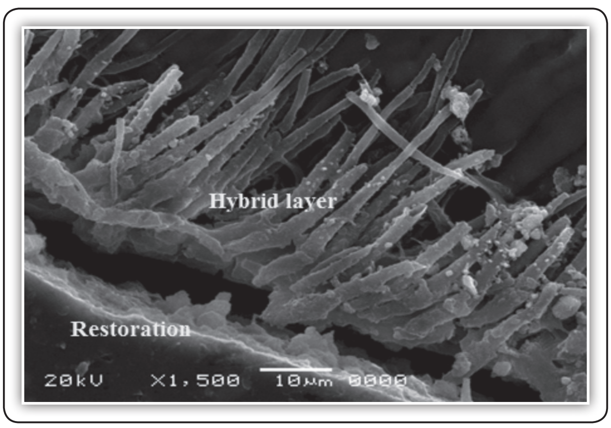

Fig. (3): Scanning electron photomicrograph for the resin dentin interface (at 1500X) of Kalore six months storage showing gap at the interface.

DISCUSSION

In this study, two types of low shrinkable resin composites were used with their adhesive systems (Filtek P90 Silorane and kalore that categorized as a low shrinkage resin composite). Silorane molecule presents a siloxane core with four oxirane rings attached to each other, that open upon polymerization to bond with monomers and seems to be one of representatives as low-shrinkage composites[8]. While, Kalore employs high molecular weight urethane dimethacrylate monomer and high filler content to achieve low shrinkage. The new Dupont molecule (DX-511 of Kalore resin composite) is a recent monomer based on urethane dimethacrylate. This monomer has a long rigid molecular core and flexible arms in the structure. The long rigid core and high molecular weight monomer prevents the monomer deformation and reduces polymerization shrinkage. Since it contains only a small number of carbon double bonded C=C, which is a factor of polymerization shrinkage [4]. The different polymerization mechanism presented by DX511 monomer of Kalore and cationic ring-opening of Silorane which have low-shrinkage nature, result in lower polymerization contraction stresses [9].

The adaptation at the resin-cavity interface is greatly influenced by the amount of polymerization shrinkage and also could be affected by increasing the number of cavity walls (C-factor) [10]. Three C-factors (C1 flat dentin, C3 class II MOD cavity and C5 class V) representing less and high bonded surfaces, were used in this study.

1-Effect of types of restorative material on microleakage;

The data in table (2) revealed that Silorane with its adhesives (two step selves etch) exhibit less microleakage, followed by kalore with its adhesive (G-aenial bond). Silorane System Adhesive is a two-step adhesive that based upon its interaction with tooth surface up to a depth of a few hundred nanometers can be categorized as an 'ultra-mild' self-etch adhesive [(11)]. It comprises a separate primer and adhesive resin that both contain silane treated silica and therefore are relatively viscous. The primer and adhesive resin are separately cured, resulting in a typical two-fold bonding layer with a thickness of about 10–20 mm which could be result in good bonding [(12)]. In addition, the two-layer build-up of and the highly hydrophobic nature of adhesive resin can be expected to have sealed dentin better than G-aenial bond [(13)]. Water uptake through osmotic effect of dentin, which may cause weakened tooth restoration interface, could blocked better by Siloane adhesive system [(14)]. Finally, the relatively thick layer of adhesive may also have acted as an elastic buffer, thereby having partially compensated for the shrinkage stress rapidly developed during polymerization of resin composite. A two-step adhesive generally reaches a higher bonding effectiveness than a one-step adhesive [(15)]. Also, Silorane based composite resin possess two key advantages: polymerization shrinkage lower than 1% due to the presence of oxirane monomers and increased hydrophobicity due to the presence of siloxane in its composition [(2,3)].

On the other hand the Kalore with its adhesive (one step self etch adhesive) showed amount of microleakage more than silorane, this could be due to the acidity of one step adhesive that contain large portion of hydrophilic component which interfere with the efficiency of polymerization of adhesive monomer [(16)] .Incomplete hydrophobic sealing of G-aenial bond with Kalore cause the incomplete polymerized hydrophilic resin component that may be elute from adhesive and hybrid layer in the short term [(17)] ,unlikeness to Silorane adhesive which contains a very hydrophobic bond with separate self etching primer that convert the wet hydrophilic collagenous surface to a dry hydrophobic surface. This hydrophobic nature of the Silorane adhesive is manifested as a lack of water diffusion, which could exhibit little microleakage [(18)].

Another explanation for low microleakage of Silorane resin composite may be due to material itself in which the filler content has somewhat controversial effects on shrinkage patterns. An increase in filler volume content leads to reduce volumetric shrinkage as the resin volume is minimized, meanwhile high filler volume results in stiff materials with high elastic modulus[19)]. (Kalore is a stiff paste because of high molecular weight monomer and high filler loading. The stiffness of Kalore might affect the results of gap formation in this study. The stiffness of the composite resin seems to be a significant factor to compromise the adaptation to the cavity wall [(20).] The result of this study is in agreement with the result of Yamazaki et al,[(21)] which stated that the Silorane resin composite showed reduced polymerization shrinkage and stress, as well as significantly improved marginal adaptation compared with methacrylate resin composite. The results of this study were disagreeing with the result of Bagis et al, [(22)] that revealed the silorane-based resin composite had no microleakage for wide MOD restorations with oblique and vertical layering techniques. Also, Schmidt et al [(23)] revealed that there were no statistically significant differences in microleakage between Silorane and other resin composites. This controversy could be due to the difference in methodology and nature of their study.

2-Effect of cavity configuration (C-factor) on microleakage;

The data of the current study (figure1) revealed that both Silorane and Kalore resin materials that used with their corresponding adhesive system do not completely eliminate the microleakage with all C-factors. This could be attributed to the fact that the volume of polymerization shrinkage of new low shrinkage resin composites used in this study were still more than the stresses created at the margin of the restoration regardless the effects of the number of bonded cavity walls(C-factor) [(24)]. The compensation of polymerization shrinkage by relaxation of the resin monomers is still significantly restricted by increasing C factor [25]. This explains the presence of leakage even with lower bonded surface of C1 factor related to C5 for both Kalore and Silorane groups with no significance between them.

Flat dentin (C1) showed less leakage in all tested groups. This may be explained by the fact that the wall-to-wall shrinkage with one bonded surface was decreased and the chance for gap formation was subsequently decreased. Where, the composite relaxation provided by the unbonded surface was more efficient for decreasing and relieving the shrinkage stresses generated during the polymerization reaction [26]. On the same basis, the leakage score of C5 was higher than C3 which included less bonded surface then C5 factor in all tested groups.

These results are in agreement with Wattanawongpitak et al, [27] who stated that cavities with a low C-factor had lesser marginal gap values than cavities with higher C-factor. The finding of this study counteracts the result of El-Marhomy et al, [28] which revealed that there is no marginal gap at the dentin-composite interface in the different tested C-factor preparations. This may be due to different in material or methods. Also, the results showed that the leakage in C5 was found to be significantly more than the leakage of C3. A possible explanation for the high leakage with high C factor the unbounded area would facilitate composite plastic deformation during polymerization before the gel point is reached, thus reducing the final shrinkage stresses values. High C-factor which has less free surface area to compensate for polymerization shrinkage stress with flow of resin resulted in different dentinal properties, which could affect microleakage [29]. The greater the C-factor the greater the shrinkage and its stress and this situation is worse in considering the application of composites in cavities with high C-factor [30].

In view of material wise used in this study and as the results revealed that the high C-factors (C5) showed high leakage score of Silorane and Kalore, while low leakage score of Silorane and Kalore was obtained from low C-factor (C1). This finding was confirmed by the fact that the adaptation at the resin-cavity interface was influenced by the amount of polymerization shrinkage. This shrinkage leads to stresses that not relieved by flow of the material, which still more than the dentin bonding agents of both Silorane and Kalore resin composite that have high C-factor number (C5). On the other hand, lower C-factor number (C1) allowed more resin composite relaxation that decreased the shrinkage stresses generated during the polymerization reaction leading to less leakage [31].

3- Effect of storage time on the microleakage:

The results of the present study revealed that all resinous materials have relative better marginal adaptation at one-month storage time. May be due to the short time that lapse of water storage or may be due to the strength of the adhesive system itself through this period that lead strong hybrid layer, therefore, may resist debonding and give a good marginal seal [32]. The water uptake by resin-based composite occurs as soon as the resin composite is exposed to water and the amount of water uptake is time dependent where it increases by time. The water sorption affects the tooth tissue restoration bond through oxidation, hydrolysis and plasticization [33].

The data from figure (2) of Silorane and Kalore showed high leakage score at six months storage time. This might be due to hydrolytic degradation of the resin and collagen fibers in the submicron spaces of the hybrid layer increase with the increased exposure to water [34]. In fact, during long-term water storage, the resin absorbs significant amount of water and consequently swelling of the resin may result in the closure of any space between the bonding resin and dentin surface [35]. Conversely, stresses may simultaneously be induced at the bonding resin-dentin interface, which may pull the collagen fibers into the hybrid layer and resin, leading to tearing along the bonded interface as the collagen fibers become weaker over time from hydrolysis [36]. The increase storage period allows increase water uptake, that lead to increased permeability and increase the hydrolytic degradation of the material [37].

In a comparison between the leakage score of Silorane groups and Kalore groups, the lower microleakage scores was obtained with the Silorane could be attributed to the ring opening chemistry of the Silorane system and the use of different nature of the Silorane system adhesive. Silorane based composite resin possess two key advantages: polymerization shrinkage lower than 1% due to the presence of oxirane monomers and increased hydrophobicity due to the siloxane in its composition[38]. Hydrophobicity of Silorane backbone and its Oxirane rings were not hydrolyzed because the monomer was immiscible in water with difficult hydrolysis [39].

Kalore with its adhesive (G-aenial bond) is One-step self-etching systems, which composed of high concentration of hydrophilic resin monomers, ionic resin monomers or both, creating thin coatings that may inhibit oxygen and may result in a poorly polymerized adhesive layer [16]. The monomers are prone to phase separation because they behave like a permeable membrane after polymerization as the solvent evaporated from the solution. This is due to the lack of a non-solvent hydrophobic adhesive layer, which allows for rapid dentinal fluid transudation across the polymerized adhesives [40].

The present study in agreement with the results of a study by Curtis et al, [41] reported lower microleakage of Silorane resin composite that attributed to the size and morphology of filler particles within the material affect water absorption. The results of the current study were controversy with the study by Bagis et al, [24] which showed that wide Class II cavities restored with Silorane composite resin exhibited no microleakage and the margins were completely sealed. This variation could be due to differences in methods.

CONCLUSIONS

Under the circumstances of this study, the following conclusions were suggested:

1- C-factor significantly affected on the marginal seal.

2- Long term storage in water dramatically increased microleakage.

3- The type of restorative material is significantly affected the marginal adaptation.

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