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ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2018, 7(12): 71-76

Microleakage of Two Porcelain Laminate Veneer Materials with Different Types of Class V Cavity Restoration (A Comparative *In-vitro* Study)

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ABSTRACT

Introduction: *Porcelain laminate veneer is considered a successful restoration if it is managed to survive in the oral cavity which depends on its sealing ability.* ***Aim:*** *To investigate and evaluate the cervical microleakage of porcelain veneers restorations fabricated from 2 types of CAD/CAM ceramic laminate bonded to teeth with different class V cavity filling material.* ***Materials and Methods:*** *Total 48 sounds, crack-free human upper first premolar extracted for orthodontic causes were selected for this study. Teeth were divided randomly into 2 study groups and further subdivided into 3 subgroups (8 samples each).* ***Results:*** *The statistical analysis have shown that the type of ceramic restoration and the composite filling had a highly significant effect on cervical microleakage and the interaction between the main factors was also highly significant. The results showed that the lowest mean of cervical microleakage sum was recorded for Group B3 (1056.279 ± SD) which is considered statistically significant compared to Group B1 (1495.030 ± SD) and Group B2 (1546.446 ± SD) and statistically highly significant compared to Group A1 (3180.705 ± SD), Group A3 (1837.429 ± SD) while Group A2 recorded the highest mean of microleakage sum (3210.037 ± SD).* ***Conclusion:*** *The type of ceramic restoration and the type of class V composite filling both had highly significant effects on the cervical microleakage mean. Cerec CPC veneers had significantly lower microleakage mean as compared to IPS e.max CAD veneers. The type of class V composite filling within 0.5 from the cervical finishing line of porcelain veneers that was filled with different composite filling had significantly higher microleakage mean compared to groups filled with the luting resin cement only.*

Keywords: Laminate veneers, CAD/CAM, IPS e.max CAD, Cerec Blocs CPC, Filtek Z350, Ceram.X, Cervical microleakage

INTRODUCTION

A charming smile displaying an even line of natural, gleaming white teeth is a major determinant that affects the expression of the face which in consequences effects the non-verbal communication. Porcelain laminate veneers can change the smile and offer a conservative approach to restoring anterior teeth. In clinical practice, the clinical impasse is whether or not to remove the existing composite restorations with no indications of caries or acceptable surface that is a substrate-less favorable to bond onto enamel. IPS e.max CAD ceramic was introduced as a lithium-disilicate CAD/CAM material that offers greater translucency compared with other ceramic core materials [1]. Another glass-ceramic block has been developed for (CAD/CAM) technology in an attempt to improve optical properties of glass-ceramic restorative materials known as CEREC Blocs C PC which is fine-structured feldspathic ceramics characterized by optimal light conducting effects and white fluorescence.

Microleakage is considered to be a critical factor influencing the survival of dental restorations. Volume changes occurring by the oral thermal alterations will cause a gap formation and microleakage. Dye penetration technique is widely used to detect microleakage due to easy manipulation, easy analysis of the results [2].

It has been suggested that the shrinkage of resin cement in the adhesive layer could generate micro-spaces in addition to the difference in the coefficients of thermal contraction of bonded surfaces, a marginal gap may form after exposure to a thermal shock in the oral environment with subsequent fluid percolation and degradation of bonded surfaces due to hydrolysis or recurrent caries would be expected, which in turn results in increased microleakage of the porcelain laminate veneers [3].

PATIENTS AND METHODS

Total 48 caries-free upper first premolars teeth were extracted for orthodontic reasons. The teeth were visually examined with blue light transillumination to ensure that the crown is free of cracks. Teeth were cleaned from any attached soft tissue then were hand scaled and polished with fluoride-free pumice and stored in saline solution at room temperature until the time of the experiment [4].

Teeth were randomly divided into 2 groups which were further subdivided into 3 subgroups with 8 samples in each group:

Group A: Teeth were restored with veneers made from lithium disilicate ceramic CAD/CAM blocks (IPS e.max CAD, Ivoclar/Vivadent, Germany).

- Group A1: Contain standardized class V filled with Filtek™ Z350 XT universal restorative nanofilled composite (3M ESPE, Germany)
- Group A2: Contain standardized class V filled with Ceram.X nano-ceramic composite (Dentsply Sirona, Germany)
- Group A3: Contain standardized class V without composite filling left to be filled with the resin luting cement
- Group B: Teeth were restored with veneers made from CEREC CAD/CAM blocks (CEREC CPC, Dentsply Sirona, Germany).
- Group B1: Contain standardized class V filled with Filtek™ Z350 XT Universal Restorative nanofilled composite (3M ESPE, Germany)
- Group B2: Contain standardized class V filled with Ceram.X nano-ceramic composite (Dentsply Sirona, Germany)
- Group B3: Contain standardized class V without composite filling left to be filled with the resin luting cement

All specimens of A and B groups received a standardized class V cavity on the buccal surface. All cavities were prepared 2 mm above cementoenamel junction in order to keep the restoration within enamel boundaries [5]. The samples were mounted on the dental surveyor. After the cavity was prepared for each tooth, it was dried and acid etching of the cavity was done with 37% phosphoric acid etchant gel (SDI super Etch, Australia) following manufacturer's instructions. Then the cavity rinsed and a Single Bond Universal Adhesive (3M ESPE, Germany) was applied to the etched enamel and dentin, and light cured for 15 seconds.

Filtek Z350 XT nanofilled composite resin (3M ESPE, USA) was applied to the cavity of Group A1 and Group B1 while Ceram.X nano-ceramic composite resin (Dentsply Sirona, Germany) was applied to the cavity of Group A2 and Group B2 and light cured for 20 seconds according to the manufacturer's instructions. The composite restoration was finished and polished. Putty condensation silicon impression material was used to fabricate a silicone index for each tooth in all groups before the preparation in order to be capable of assessing the accuracy of tooth reduction [6].

Standardized preparations were done for all the teeth by using ceramic veneer system preparation bur kit. The buccal reduction was 0.4 mm at the cervical third and 0.5 mm at the middle and occlusal thirds. Finally, the preparation was finished and the digital impression was made for all the teeth by using Trios 3 shape intraoral camera (Sirona Dental Systems). CAD/CAM veneer fabrication: Sirona inLab CAD SW 16.1 was used with CEREC inLab MC XL (Dentsply, Sirona Dental Systems, Germany) to designate veneer restoration. Veneers milled from IPS e.max CAD blocks (Group A) were in their pre-crystallized status after milling where they had a violet bluish color which was changed to a tooth shade after crystallization firing, while the veneers milled from CEREC CPC blocks (Group B) were in fully-crystallized status, but they need characterization which was done with a final firing with VITA accent paints.

Cementation of Veneer

The inner surface of all veneers was etched with 9% hydrofluoric acid gel (Ultradent Porcelain Etch, Ultradent Products, USA) for 90 seconds according to the manufacturer instructions then veneers were rinsed and air dried. Byproducts precipitate on the surface were removed by etching the restoration with 37% phosphoric acid etching gel (SDI super Etch, SDI, Australia) and then washed and air dried [6]. Silane coupling agent (Ultradent Porcelain Etch, Ultradent Products, USA) was applied over the internal surface of the veneers. All the prepared teeth were cleaned etched and then Single Bond Universal Adhesive (3M ESPE, USA) was applied to the prepared teeth and to the silanized surface of veneers. The cementation was done with 3M RelyX veneer resin cement (3M ESPE, Germany). The cement was applied to the inner surface of the veneers and the veneers were positioned on the teeth occluso-cervical and held in place with Optrastick with light pressure. The seating pressure was controlled by cementation device at 1 kg [7]. Then each veneer light was cured for 40 s from buccal, mesial, distal and occlusal. Finally, the margins were finished and polished. The specimens were stored at 37°C in distilled water for 2 weeks [1]. All specimens were subjected to thermal cycles in order to simulate the oral cavity environment. The thermocycling was done using an automatic thermocycling device 500 cycles in water between (5°C to 55°C) with dwell time at least 20 seconds. Nail varnish was used on each specimen to paint the root surface at CEJ to avoid dye penetration from the root surface.

Microleakage Test

Microleakage existence is determined by the appearance of blue color at the tooth-restoration interface and tooth-cement interface. The draft of microleakage was specifically registered for the cervical margin with the help of a digital microscope and a millimeter graph paper to measure the length of microleakage which appeared as a blue stain from the 2% methylene blue dye.

The measurement of microleakage was accomplished by using the Image J software program. The calculation was achieved at first to each specimen by measuring the graph paper known distance and entering its value in µm. Then the cervical outer interface, cervical inner interface and total microleakage measurements of each sample were recorded then the mean was calculated.

RESULTS

The lowest mean of microleakage was recorded for Group B3 (1056.279 ± SD) which was restored with CEREC CPC veneers plus resin cement Cl V filling, while the highest mean value of microleakage was recorded for group A2 (3210.037 ± SD) which was restored with IPS e.max veneers plus Ceram.X Cl V filling) (Table 1).

Table 1 Descriptive statistics: minimum, maximum, mean, std. deviation, of cervical microleakage

Groups	Subgroups	Minimum	Maximum	Mean	Std. Deviation
A	A1	1805.387	4251.879	3180.705	860.405
	A2	2678.706	4011.779	3210.037	486.504
	A3	1039.419	2147.855	1837.429	369.214
	Total	1039.419	4251.879	2742.724	875.544
B	B1	1202.406	1767.356	1495.03	218.743
	B2	1275.324	1850.649	1564.446	208.186
	B3	753.087	1239.143	1056.279	170.43
	Total	753.087	1850.649	1371.918	299.018

The two-ANOVA test has revealed that the type porcelain veneer restoration had a highly significant effect on microleakage sum ($p \leq 0.01$), similarly, the presence of different types of class V filling materials had a highly significant effect ($p \leq 0.01$) also the interaction of the effects between those two factors had a significant effect on the microleakage sum ($p<0.05$) as we can see in (Table 2).

Table 2 Two way ANOVA test of the mean value of the microleakage sum of all groups

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	33602249.946	5	6720449.990	32.689	0.000	0.796	1.000

Groups	22549284.100	1	22549284.100	109.681	0.000 [HS]	0.723	1.000
Subgroups	8963588.990	2	4481794.490	21.800	0.000 [HS]	0.509	1.000
Groups* Subgroups	2089376.830	2	1044688.420	5.081	0.011 [Sig.]	0.195	0.792
Error	8634774.310	42	205589.864	-	-	-	-
Total	245400369.000	48	-	-	-	-	-
Corrected Total	42237024.300	47	-	-	-	-	-

The results of the LSD test showed that Group A1 has more microleakage than Group A3 (p>0.01). Also, the results showed that Group A2 has more microleakage than Group A3. On the other hand, Porcelain veneers groups restored with CEREC Blocs C PC (Group B1 and Group B2) showed a non-significant (p>0.05) effect of the presence of Filtek Z350 and CeramX class V filling on the microleakage sum while the group B1 shows more microleakage than Group B3 (p<0.05). Also, it has been found that Group B2 shows more microleakage than Group B3 as shown in Table 3.

Table 3 Least significant difference test (LSD) to compare between the subgroups among the same group

Groups	(I) Subgroups	(J) Subgroups	Mean Difference (I-J)	Sig.
A	A1	A2	-29.333	0.898
		A3	1343.276	0.000
	A2	A3	1372.609	0.000
B	B1	B2	-69.417	0.761
		B3	438.751	0.040
	B2	B3	508.167	0.030

DISCUSSION

Microleakage is one of the most common factors of porcelain veneers failure especially in the cervical area because the enamel rod orientation at the cervical area may lead to increased microleakage at cervical interfaces, therefore, this present *in vitro* study was performed to evaluate the cervical microleakage of porcelain veneers restorations manufactured from 2 types of CAD/CAM ceramic blocks bonded to teeth with 3 different types of class V filling materials [6].

Ceramic laminates are indicated not only to restore malformed, malpositioned or discolored teeth where mainly the substrate is the enamel and/or dentin but also in situations where resin composite restorations are present on the tooth to be restored so all the specimens in this *in vitro* study received class V cavity filled different type of composite filling material on the buccal surface [8,9]. Bonding of porcelain veneers to an existing composite restoration instead of enamel which is considered as weak bonding point may lead to cervical microleakage as a result of the difference in thermal expansion of the tooth, ceramic and composite resin at this critical area from the veneer margin [10].

Measurement of microleakage was done by measuring the cervical microleakage in μm, in which the cervical area was divided into the inner interface and outer interface then the mean was taken to measure the total microleakage in the cervical area [11].

According to the results of two-way ANOVA test, highly significant effect on microleakage was found among the types of porcelain veneers this finding agrees with Hooshmand, et al., who reported there is a correlation between the type of ceramic restoration materials used and microleakage [12]. But it disagrees with Hekimoglu, et al., who concluded that the type of porcelain material had no significant effect on the microleakage at the cervical margin [13]. This may be due to different ceramic restoration used, different restoration fabrication methods, using of artificial aging method.

According to results LSD test, Cerec CPC (Group B3) had significantly less microleakage than that of the IPS e.max veneers (Group A3), the same finding was noticed when comparing between Group (B2, A2) and Group (B1, A1) with the highest microleakage mean recorded for IPS e.max veneers Group A1. Microleakage at the cervical area influenced by the contraction stress is induced during the polymerization shrinkage of the resin cement which result in the micro-gap formation at the weaker bond interface [6]. Another factor that influences microleakage has been found in the differences in the coefficient of thermal expansion between the different types of porcelain restoration materials and the tooth. These differences result in stress formation at the bond interface during temperature changes results in micro-cracks propagation and eventually gap formation and microleakage [14].

In order to reduce microleakage, it is a wiser option to choose restorative materials with a coefficient of thermal expansion close to the CTE of enamel and dentin of human tooth which will result in lesser gap formation between the porcelain-tooth interfaces during thermal changes in the oral environment [14]. Cerec CPC ceramic have the least difference and the closest coefficient of thermal expansion to both enamel and dentin as compared to IPS e.max ceramic which is close to CTE of enamel but large difference to CTE of dentin which may be the cause of the reported lower microleakage mean of Cerec CPC veneers which translate into better performance during the thermal stressing of the material.

Another method to decrease the microleakage of dental restorative materials is the use of a material with a lower modulus of elasticity [15]. Cerec CPC had a significantly lower modulus of elasticity (45 ± 0.5 GPa) as compared to IPS e.max ceramic (95 ± 5 GPa). The combination of lower modulus of elasticity and lower strength of Cerec CPC ceramic is translated into higher resiliency compared to IPS e.max ceramic. This result in better elastic buffer and compensation for resin cement shrinkage stress which is another explanation of the lower microleakage mean of Cerec CPC veneers.

According to the two-way ANOVA test, the present study showed a highly significant effect among the presence of different type of composite filling on the microleakage mean of porcelain veneers. This finding agrees with Sadighpour, et al., who reported that ceramic veneers with class IV composite filling had significantly higher microleakage compared to control [16].

According to the result of LSD test, Group A1 (which restored with Filtek z350 class V filling) showed significantly higher microleakage mean as compared to Group A3 (which has class V filled with luting resin cement only) and the same result was obtained when compared Group A2 (which is restored with Ceram.X class V filling) with Group A3. This result may be explained by the presence of multiple interfaces and different materials in Group A1 and Group A2 in which there were 3 different interfaces: tooth-composite filling interface, composite filling-luting resin cement interface, and luting resin cement-veneer interface. These multiple materials have different coefficient of thermal expansion and contraction which reveal the different behavior of the various materials during thermocycling procedure which may cause a larger gap and increased microleakage and this agrees with the study done by Celik, et al., who reported that due to the difference in thermal expansion between luting agent and tooth, the thermal cycling of a restoration between high and low temperatures may cause deterioration of the bond between the luting agent and tooth [17].

Some studies have suggested that old composite fillings could be removed before teeth are restored with PLVs and this agreed with our study in which the old composite restoration could be removed and the remained cavity was filled only with luting resin cement for better reduction of microleakage possibility. But it disagrees with Peumans, et al., who concluded that removing an old composite filling and replacing it with a new restoration has the disadvantage of removing sound tissues. However, the main reasons for the failure of laminated veneer in *in vivo* studies are marginal defects and subsequent microleakage. Defects were especially observed at the locations where the existing fillings were present. In such locations, caries and severe marginal discoloration were observed. As shown by the two-way ANOVA test, the effect of the interaction between the type of ceramic restoration and the type of class V composite filling material on the microleakage mean values was highly significant.

CONCLUSION

Within the limits of this *in vitro* study, the following conclusions were obtained:

- The type of ceramic restoration and the type of class V composite filling both had highly significant effects on the cervical microleakage mean of porcelain veneers
- The groups in which class V cavity filled with luting resin cement only show lesser cervical microleakage mean as compared to groups with class V cavity filled with Filtek Z350 or Ceram.X composite filling
- Cerec CPC veneers had significantly lower microleakage compared to IPS e.max CAD veneers

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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