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Three Translucency Heat-treatment of Two Ceramic CAD Milling Blocks and their Effect on Leakage and Film Thickness

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ABSTRACT
This study aims to evaluate and compareleakage and film thickness when applying three translucency heat-treatment to two CAD Milling blocks(Emax CAD and Amber Mill) considering temperature and holding time for translucency heat-treatment.120 cemented laminate veneers were randomly divided into two groups, Group 1: (Amber Mill, N=60), and Group 2: (Emax CAD, N=60). Then, they were divided into 3 subgroups, based on thermal temperature. the measurements of film thickness and leakage were applied.a two-way ANOVA was used. Student's t-test was used to compare between two materials.It has been found that the firing cycles and translucency levels had a significant effect on both leakage and film thickness.The degree of translucency and direction of manufacturing during firings has direct effect on both film thickness and leakage. there is a direct relationship between increasing the degree of translucency of Amber Mill and leakage and film thickness.

keywords: Amber, film thickness, Leakage, lithium disilicate, repeated firing, translucency heat-treatment.

INTRODUCTION

The aesthetic aspects of dental treatment have become increasingly important to patients. This enhances the demand for high translucent all-ceramic restorations. In fact, glass-ceramic materials gained broad acceptance because of their exceptional translucency and appropriate strength. They provide a strong bond that relies on micromechanical interlocking and chemical bonding to resin cement. Lithium disilicate restorations are the most common type of ceramic restorations[1].

Moreover, adding pigments to the glass frit can modify ceramic translucency. However, the concluding results depend on microstructure and the composition phasemore than on adding any other compound. Ceramics translucency can be affected by size, volume, and crystals density. Improved translucency results are achieved when light wavelength is longer than dimension of crystal. Translucency can be also enhanced by a fine-grained microstructure. Low crystal density makes the ceramic more translucent when scattering increases [2-7].

A new modification of Lithium disilicate is Amber restorations, which is nano lithium disilicate material. The manufactures claims that its translucency issimilar to that of the enamel layer of the natural teeth. The high aesthetics of Amber enables the restorations to replace damaged natural teeth appropriately.The resulted translucency depends on the temperature and holding time for Amber Mill heat-treatment.According to the schedule of translucency heat-treatment, a wide range of translucency can be obtained.

Additionally, estimation of cement film thickness is necessary to determine the adaptation of the restorations and their fitness. reported that the methods adopted to measure marginal fit include cross section view, direct view of crown on die under the electron microscope, impression replica technique, profilometry, SEM, image analysis, and 3D scanning[8].

The cross-section technique has been used to measure marginal fit of cemented inlays, veneers, metal ceramic crowns, and all ceramic crowns. It is done by cutting the specimen after cementation in a horizontal section and measuring the width of the cement layer. Second, the direct view is a non-destructive technique,which is often used to measure the distortion during the manufacturing process of the restoration where the specimen is generally examined with direct microscopic view of the interface.However, measurements with an optical microscope might be faulty due to the limited depth of the field. [9-16].

Variation in the internal gap values can create stress concentrations, which may reduce the restoration strength and cause its fracture. Furthermore, the gap size is affected by the thickness of the dental cement layer along the axial walls of the preparation; and this layer influences the seating of the restoration. Many factors also affect film thickness, including preparation margin design, marginal configuration, surface roughness, die spacers, cementation pressure, duration of cementation, powder/liquid ratio of the cement, type of cement, and cementation technique.There issystematic review and meta-analysis that summarize the scientific literature assessing the effects of various parameters on the marginal and internal fit of porcelain laminate veneers. It has been concluded thatfor the internal gap, the differences were significantly in favor of the pressed type. The butt joint veneer preparation design was remarkably superior to the palatal chamfer design in terms of marginal fit[17-18].

Microleakage measurement provides an assessment of the marginal adaptation by evaluating dye penetration between the tested material and the tooth structure. Thisis the most commonly used methodfor assessing the sealing efficiency of a restorative system and the longevity of this restoration. Thus, it is essential to investigate it. Generally, the success of any material is assessed by its longevity, sealing ability, and biocompatibility in an oral environment. Microleakage is a major factor influencing the longevity of dental restorations.

Many researchersevaluated the marginal accuracy and microleakage of machinable laminate veneers (IPS-Emax CAD, Vita Suprinity, and Celtra-Duo); and they found that lithium silicate restorations, particularly the partially crystalline form, introduced better marginal accuracy and microleakage than lithium disilicate restorations. [19].

In addition, translucency adds a life-like appearance to the restorations. It is increased by high transmission of light and low absorption.[20]. AmberMill is one of the newly presented lithium disilicate milled ceramics, with new technology (nano lithium disilicate), to control translucency based on firing temperature and holding time. Limited insufficient researches were found in this field. Therefore, this study aims to determine the effects of many firing temperatures (degree of translucency)on film thickness and leakage of Amber lithium disilicate milled ceramic. Then, they are comparedwithone fixed degree firing temperature of IPS-Emax CAD threetranslucencies (high translucency (HT), Medium translucency (MT), and law translucency (LT)), where both have three translucency heat-treatment, but differ in direction of manufacturing technique.

Aims

This study aims to evaluate and compare the leakage and film thickness of two different three translucency heat-treatment CAD Milling blocks according to temperature and holding time for translucencyheat-treatment,Amber Milling blocks and Emax CAD

MATERIAL AND METHODS

Teeth preparation

First, 120 human anterior teethwere extractedfor periodontal problems. They were collected from surgery clinics at College of Dentistry, Qassim University. All the teeth were inspected to ensure thatthey are free from old restorations, caries, and cracks. Then, they were sterilized and stored in normal saline at room temperature. After that, the teeth were prepared to be restored with indirect labial laminate veneer restorations, with 0.3 cervical and proximal chamfer finish line, and wrapped around incisal preparation. The Proximal preparation was slightly extended to the contact area. The previously prepared split-silicone index was used to control the amount of teeth preparation. Finally, the teeth were stored in saline solution at room temperature.

Laboratory procedures

An individual heavy and light poly-vinyl siloxane impression material was taken for each prepared tooth (poly-vinyl siloxane Virtual, Ivoclar - vivadent). Then, it was poured using (type IV) for stone die fabrication.

Furthermore, all the prepared teeth were randomly divided into two main groups based on the ceramic materialsused:Group1: (Amber Mill, N=60) (C12 Lithium Disilicate-Based CAD/CAM Blocks Amber® Mill), and Group 2: (Emax CAD, N=60) (C 14 Ivoclar IPS e.max CAD). Next, each group wasdivided into 3 subgroups with 20 samples in each, according to the heattreatment temperature of the ceramic material used (Subgroup 1: (LT), Subgroup 2: (MT), and Subgroup 3: (HT)). After that, the groups were arranged as shown in Table (1). For each group and subgroup, all labial laminate veneers restorations were fabricated according to the manufacturer'sinstructions, with different degrees of translucency heat-treatment temperature.

Table 1: Arrangement of samples according to degree of translucency heat-treatment temperature

Gr I Amber Mill Blocks	No of Samples	Crystallization temperature	Gr II Ivoclar IPS e.max CAD	No of Samples	Crystallization temperature
Subgr. 1 HT Amber Mill Blocks	20	830°C	Subgr. 1 HT IPS e.max CAD Blocks	20	840-860 °C
Subgr. 2 LT Amber Mill	20	840°C	Subgr. 2 LT IPS e.max CAD Blocks	20	

Blocks					
Subgr. 3 MT Amber Mill Blocks	20	855°C	Subgr. 3 MT IPS e.max CAD Blocks	20	
N=60			N=60		

Bonding of laminate veneers

For each group and subgroup, the fabricated laminate veneers were cemented to the labial surfaces of the prepared enamel, according to the manufacturer's instructions (I-Cem Self Adhesive, KULZER GmbH LeipzigerStraße 2 63450 Hanau Germany). The teeth contacting surfaces of veneers were etched. The prepared teeth surfaces were rinsed and lightly dried. The mixing tip of the automix syringe was placed; andmixed cement was dispensed evenly directly into the restoration. Then, the veneers were seated. Next, positive pressure on the restoration was maintained for 2.5 minutes. The excess material at the margin of the restoration was removed with a brush after briefing light polymerization for 1 – 2 seconds. After that, the interproximal areas were cleared with floss. All-ceramic veneers restorations and all restorations at the margins were light cured for 30 seconds from each side. Moreover, pressure was applied on the inserted restoration again for 2.5 minutes. Finally, iCEM Self Adhesive was completely auto-polymerized within 7 minutes.

Measurements tests

After cementation, the teeth in their groups and subgroups were randomly subjected to two types of measurement, film thickness in part 1, and leakage in part 2, as displayed in Table (2).

Table 2: Grouping samples according to measurements tests

Part 1: Measuring film thickness					
Gr I Amber Mill Blocks	No. of samples		Gr II Ivoclar IPS e.max CAD	No. of samples	
Subgr.1HT Amber Mill Blocks	12	N=36	Subgr. 1 HT IPS e.max CAD Blocks	12	N=36
Subgr. 2LT Amber Mill Blocks	12		Subgr. 2 LT IPS e.max CAD Blocks	12	
Subgr. 3MT Amber Mill Blocks	12		Subgr. 3 MT IPS e.max CAD Blocks	12	
PART 2: Measuring leakage					
Subgr. 1HT Amber Mill Blocks	8	N=24	Subgr. 1 HT IPS e.max CAD Blocks	8	N=24
Subgr. 2LT Amber Mill Blocks	8		Subgr. 2 LT IPS e.max CAD Blocks	8	
Subgr. 3MT Amber Mill Blocks	8		Subgr. 3 MT IPS e.max CAD Blocks	8	

Part 1: Film thickness measurements

The total number of cemented laminate veneers samples (72) was divided into two main groups according to the materials used. Group I included Amber cemented laminate veneers samples (36); and they were subdivided into 3 subgroups according to the degree of translucency heat-treatment temperature of Amber blocks, with n= 12 (Subgr. 1(LT), Subgr. 2(MT), and Subgr. 3 (HT)). Group II involved Emax cemented laminate veneers samples (36); they were subdivided into 3 subgroups with n= 12 according to the degree oftranslucency heat-treatment temperature of Emax blocks (Subgr. 1(LT), Subgr. 2(MT), and Subgr. 3(HT)). In addition, all cemented veneers teeth were sectioned mesiodistally using a low-speed diamond saw with water coolant (IsoMet Low Speed Saw; Buehler Ltd., Lake Bluff, Illinois, USA). The die-cement interface of the sectioned parts was examined using MA 100 Nikon stereomicroscope Japan with Omnimet image analysis software with Magnification 30X to measure the cement film thickness. For each sectioned cemented veneers teeth, 12 selected reference points cervicoincisally were measured in µm, as shown in Figure 1.

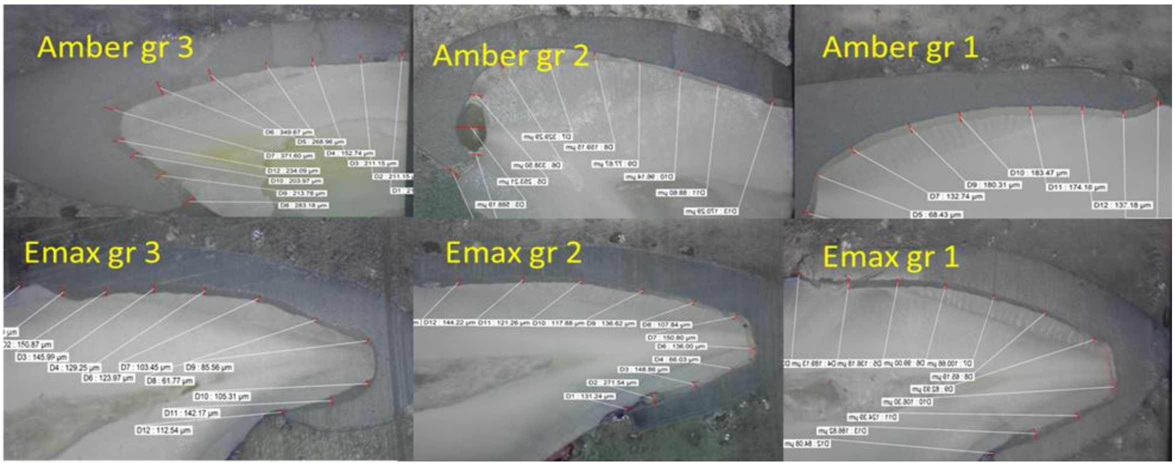

Figure 1: Film thickness measurements

Part 2: Leakage measurements:

The total number of cemented laminate veneers samples was (48). It was divided into two main groups according to the materialsused. Group I included Amber cemented laminate veneers samples (24), divided into 3 subgroups (with n= 8) according to the degree of translucency heat-treatment temperature of Amber blocks:Subgr. 1(LT), Subgr. 2(MT), and Subgr. 3 (HT). Group II had Emax cemented laminate veneers samples (24), divided into 3 subgroups(with n= 8) according to the degree of translucency heat-treatment temperature of Emax blocks: Subgr. 1(LT), Subgr. 2(MT), and Subgr.3(HT). After cementation of laminate veneers, two layers of nail varnishcoated each tooth, except the surfaces that were covered with the laminate veneers restoration with nearly one mm all-round the margin. Moreover, wax was used to seal the root apex. All the teeth were incubated for 24 hours. Next, the teeth with the cemented veneers in the two main groups (I and II) were coded randomly. After that, they were divided into 3 subgroups, and all the samples were thermo-cycled to 1000 with dwell time =30 seconds and transfer time = 15 seconds, and with temperatures between 5 and 55°C. All the coded teeth with the cemented veneers were immersed in 2% methylene blue dye for 24 hours. Then, the excess dye was removed from all cemented veneers teeth under running water for 10 min, and all the samples were dried. Furthermore, all the cemented veneers teeth were sectioned mesiodistally under water coolant using a low-speed diamond saw (IsoMet Low Speed Saw; Buehler Ltd., Lake Bluff, Illinois, USA). The die-cement interface of the sectioned parts was examined using MA 100 Nikon stereomicroscope Japan with Omnimet image analysis software with Magnification 30X, to measure the dye penetration depthat both the cervical and incisal margins.

The microleakage was scored using 0-1 score scale.Figure 2shows the following:

At the cervical margin: No dye penetrates = Score 0; Dye penetrates the cervical wall = Score 1

At the incisal margin:No dye penetrates = Score 0; Dye penetrates the enamel =Score 1.

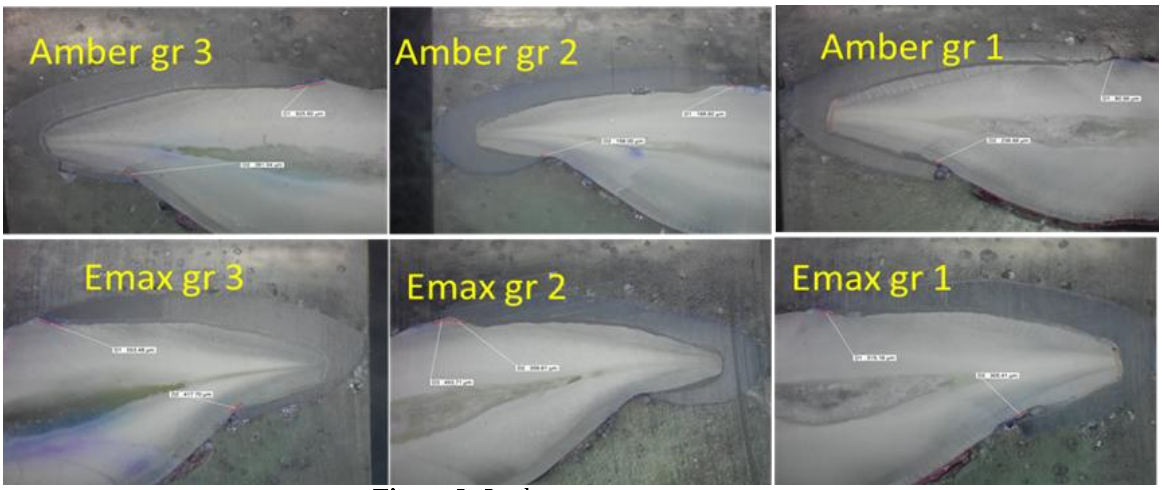

Figure 2: Leakage measurements

Statistical analysis

The Data were collected and analyzed using SPSS. The data was fed to the computer and analyzed using IBM SPSS software package version 20.0. **(**Armonk, NY: IBM Corp**)**. Regarding continuous data, they were tested for normality by the Kolmogorov- Smirnov and Shapiro-Wilk test. Besides, quantitative data were expressed as minimum, maximum, mean, standard deviation, and standard error of mean and confidence interval of mean. **A two-way ANOVA** was also performed since we aimed to evaluate the effect of the two factors (material and translucency) on leakage and film thickness. Additionally, for normally distributed quantitative variables,**a one-way ANOVA test** was applied to compare between more than two subgroups. Then, it was followed by ap**ost-hoctest (Tukey)** for pairwise comparison.**Student's t-test** was used to compare the two materials. The significance of the obtained results was judged at the 5% level.

RESULTS

Microleakage results

Emax veneers restorations showed less microleakage than Amber veneers restorations with a statistically significant difference, as presented in Figure 3.

Figure 3: (A)Microleakage; (B) Leakages

Table 3a: Two-way ANOVAto compare between materials and translucency concerningaverage leakage

Source	SS	DF	MS	F	Sig.
Material	252852.027	1	252852.027	34.722	<0.001*
Translucency	112251.611	2	56125.806	7.707	0.001*
Material*Translucency	56781.009	2	28390.505	3.899	0.028*
Error	305849.335	42	7282.127		
Total	6186627.75	48			

F, p: f and p values for the model DF: Degree of freedom MS: Mean square
SS: Type III sums of squares *: Statistically significant at p ≤ 0.05

Table 3b: Comparison between different studied groups according to average leakage

Translucency	**Material**	
	Group I Amber (A)	**Group II E-max (E)**
LT	383.9^{a} ± 52.39 (18.52)	198.0^{b} ± 87.43 (30.91)
MT	417.4^{a} ± 47.37 (16.75)	216.1^{b} ± 99.35 (35.12)
HT	428.1^{a} ± 99.97 (35.34)	379.8^{a} ± 105.8 (37.41)
F = 11.587* (p <0.001*)		

8 Replicas for each group. Data were expressed using Mean ± SD. (SEM)
SD: **Standard deviation** SEM: **Standard error of mean**
F: **F for one-way ANOVA test**; pairwise comparison between each 2 groups was done using a **post-hoc test (Tukey)**
p: p value for comparing between the studied groups
*: Statistically significant at p ≤ 0.05
Means with **common letters** are not significant (i.e., Means with **different letters** are significant)

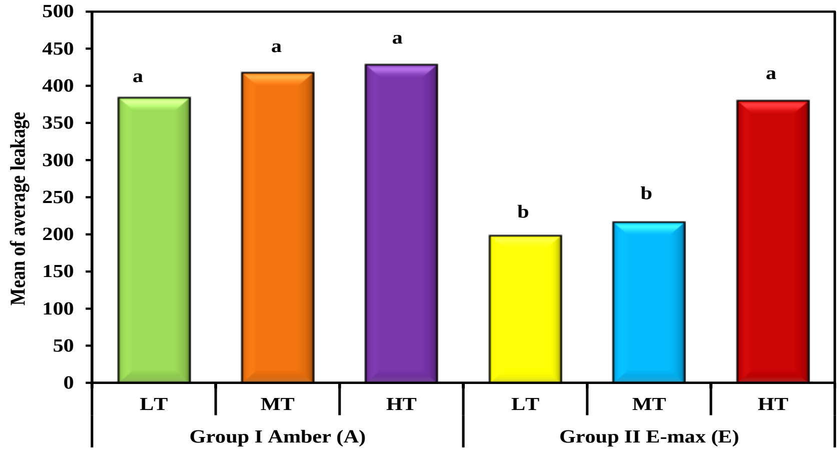

Figure 4: Comparison between different studied groups according to average leakage

Film thickness

Amber veneers restorations showed a significant increase in film thickness when compared to Emax veneers, as described in Figure 3B.

Table 4a: Two-way ANOVA to compare between materials and translucency concerning film thickness.

Source	SS	DF	MS	F	Sig.
Material	175665.41	1	175665.414	34.690	<0.001*
Translucency	14295.326	2	7147.663	1.411	0.251
Material*Translucency	52170.059	2	26085.029	5.151	0.008*
Error	334219.508	66	5063.932		
Total	2523961.29	72			

F, p: f and p values for the model DF: Degree of freedom MS: Mean square
SS: Type III sums of squares *: Statistically significant at $p \le 0.05$

Table 4b: Comparison between different studied groups according to film thickness

Translucency	**Material**	
	Group I Amber (A)	**Group II E-max (E)**
LT	156.3^{bc} ± 33.60 (9.70)	133.2^{c} ± 52.70 (15.21)
MT	241.5^{ab} ± 145.3 (41.94)	112.4^{c} ± 28.04 (8.10)
HT	243.8^{a} ± 63.73 (18.40)	99.62^{c} ± 22.73 (6.56)
F = 9.563* (p <0.001*)		

12 Replicas for each group. Data were expressed using Mean ± SD. (SEM)
SD: **Standard deviation** SEM: **Standard error of mean**
F: **F for one-way ANOVA test**; pairwise comparison between each 2 groups were done using ***a post-hoc test*** (Tukey)
p: p value for comparing between the studied groups.
*: Statistically significant at $p \le 0.05$
Means with common letters are not significant (i.e., Means with different letters are significant)

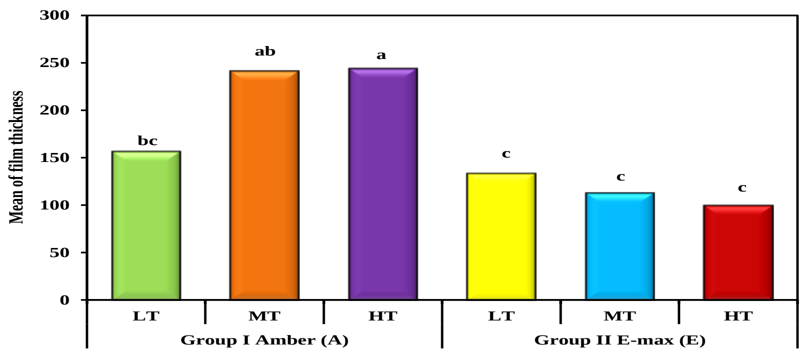

Figure 5: Comparison between different studied groups according to film thickness

DISCUSSION

In the recent years, there have been wide advances in prosthodontics dental material to increase the advantages and overcome the drawbacks of some materials. There is high competition among dental manufacturers to produce materials that can increase the satisfaction of both dentists and patients. Therefore, this study has attempted to compare between the accuracy of two groups of recent veneers lithium disilicate nano-ceramic CAD CAM materials, Amber (A)and E-max CAD(E).They were treated with three different translucency heat treatments according to the manufacturer'sinstructions.Moreover, both microleakage and film thickness were measured in both materials using different translucency heat treatments. Microleakage is considered one of the main factors used to evaluate the accuracy and durability of fixed restorations[21-22].Leakage measurements are also significant because they are considered the primary source of failure of restorations, which resultsinfurther side effects, such as marginal staining, discoloration, hypersensitivity, secondary caries initiations,periapical pathosis, and subsequent failure of restorations [1,9].

The luting resin cement materials have an important role in microleakage [23]. This is because of the stress alternation of thermal expansion coefficient at the ceramic/luting resin/enamel interface,and to the polymerization shrinkage of the luting resin cement. In addition, due to the differences of adhesive forces between the bonded interfaces, the lowest adhesive force will break the contact causing microleakage [24].Clinically, it is the main cause of invisible ingress of fluids, bacteria, and food debris. Theunadapted margincausesmicroleakage of restorative materials. Once microleakageis detected, the restoration must be replaced to avoid dangerous effect on dental pulpand pulp pathosis. Many researchers consider the presence of microleakage a significantcauseto replace the restoration, particularly in anterior veneer restorations[25-26].

There are many techniques used for measuring microleakage such as scanning electron microscope, radioactive or chemical tracer, electrochemical investigation, bacteria, compressed air, anddye penetration [27-28]. For many reasons, the dye penetration method was preferred in this research since it ischeap, and commonly applied to evaluate the good margin seal of the tooth-bonded fixed permeant restorative material such as veneers. Moreover, in this study, the staining die solution (methylene blue) was used for marginal sealing measurementfor multiple reasons that include precise evaluation of the marginal sealing, easyanalysisof the diffused indicator under the microscope, and simple application[29].

In our study, the highest mean internal film thickness was 114.96 µ for CAD/ CAM restorations (GP SIM), while the lowest mean internal gap distance was 62.38 µ.In addition, the average film thickness was115.07 for Emax restorations and 213.8 for Amber restorations. This was in disagreement with another previousstudy[30].that compared between marginal and internal adaptations of porcelain laminate veneers fabricated with heat-pressed and with CAD/CAM techniques. They found that the mean internal adaptation value of CAD/CAM veneers were 314.98 µm,

On the other hand, our study was in agreement with anotherstudy[31].where they assessed the impact of thermocycling on marginal and internal adaptations of CAD/CAM ceramic crowns (Celtra DUO, e-max AD, bilayered zirconia, and monolithic zirconia). They found thatthe lowest marginal and internal gap values among all the tested all-ceramic systems with statistical significance was the E-max CAD.

In the current study, the mean microleakage score of theemax restorations was 264.6 um, while the mean microleakage score of the Amber restorations was 409.8 um.Therefore,emax restorations showed less microleakage score than Amber restorations with statistical significance difference. The score of the emax leakage is less than that reported byanotherstudy[32].where they compared marginal microleakage of three different dental materials in veneer restoration (fiber-reinforced composite, IPS e.max Press, and 3M composites (3M ESPE)) using a stereomicroscope. They found thatthe fiber-reinforcedcomposite showed an enhanced marginal adaptability for veneer restoration.Furthermore, our current resultsare in disagreement with study[33].that evaluated the cervical microleakage of porcelain veneers restorations fabricated from 2 types of CAD/CAM ceramic laminate. They found that Cerec CPC veneers had significantly lower microleakage mean when compared to IPS Emax CAD veneers.

Our results concerning leakage were in agreement with study [34].that investigated the effects of the type of ceramic, and the influence of the type of cervical substrate on the microleakage of aged Porcelain laminate veneers. They concluded that lithium disilicate veneers had significantly lower microleakage in comparison to zirconia reinforced lithium silicate veneers.

CONCLUSIONS

Significantdifferenceswere noticed in the results of microleakage and film thickness in bothEmax CAD and Milled Amber restorations. Moreover, it was found that the degree of translucency and direction of manufacturing during firingshas direct effect on both film thickness and leakage. In addition, there is a direct relationship between increasing the degree of heat treatment (degree of translucency)of Amber milled and bothleakage and film thickness.Finally, regarding Emax CAD, there is a direct relationship between raisingthe degree of heat treatment (degree of translucency) and leakage. On the other hand, there is an inverse relationship between it and film thickness.

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Conflict of Interest
The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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