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A Comparability Between the Translucency Of different veneering materials And Aging Effect On them (In Vitro Study)

Mohamed Hazim Qassim, Nadia Hameed Hasan

Department of Conservative Dentistry, College of Dentistry, University of Mosul

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***Correspondence:**

E-mail:
mohammed.qassim@uomosul.edu.iq

Abstract

Aims: The aim of this research was to study the effect of artificial aging on the translucency of four different veneering restorations. **Materials and methods:** Twenty laminate veneers were prepared on prefabricated metal dies of upper right central incisors with incisal lap preparation design using CAD-CAM system from four different materials (Zircad Prime "ZP", DD cubeX2 ML "DD", CopraSupreme Symphony "WP", IPS E.max CAD), with 0.5 mm thicknesses. The samples were divided into four equal groups with five samples from each material, aging was done in the steam autoclave at (134c) and (0.2 Mpa) for five hours according to (ISO 13356). TP was tested using a (3nh) colorimeter. Statistical analysis was done using ANOVA at a level of significant 5%. **Results:** The mean of translucency parameter (TP) between the examined groups shows that lithium disilicate and Zircad prime (ZP) groups showed significant differences, while White Peak (WP) and Direct Dental (DD) showed no significant difference. **Conclusions**: lithium disilicate material and ZP were affected by aging, while other types of zirconia including WP and DD were not affected by aging due to their structural composition.

الخلاصة

الأهداف: تهدف الدراسة الى تقييم تأثير التقادم الزمني الاصطناعي على معامل الشفافية لأربع انواع مختلفة من مواد القشرة الرقائقية. المواد والطرق: الدراسة تمت بتحضير عشرين عينة من القشرة الرقائقية على قوالب معدنية للقاطع العلوي الايمن محضرة بتصميم (incisal lap preparation) باستخدام جهاز الكاد كام من اربعة مواد مختلفة (ثلاثي اليتريا CopraSupreme Symphony وخماسي اليتريا cubeX2ML والنوع الثالث هو ثلاثي وخماسي اليتريا المدمج معا Zircad Prime و ثنائي سليكات الليثيوم IPS E.max)بسمك ثابت (0.5 ملم). **المواد وطرائق العمل**:تم تقسيم العينات بشكل عشوائي إلى أربع مجموعات رئيسية (n=5)تم إجراء شيخوخة صناعية عن طريق وضع ترميمات القشرة الرقائقية في الأوتوكليف بالبخار عند (134 درجة مئوية) و (0.2 ميجا باسكال) لمدة (5 ساعات) وفقًا لـ معايير (ISO13356) . تم تقييم معامل الشفافية للعينات باستخدام جهاز الكلورميتير(3nh). تم تحليل البيانات باستخدام طريقة واحدة من اختبارات ANOVA عند مستوى 5٪ من المعنوية. **النتائج**: الشيخوخة الاصطناعية تقلل بشكل ملحوظ من معامل الشفافية لترميمات قشرة الزركونيا الرقائقية المصنعة من النوع المدمج من ثلاثي وخماسي اليتريا من قشرة الزركونيا الرقائقية (3Y&5Y) و ثنائي سيليكات الليثيوم..، ولكن هذا لا ينطبق على النوعين المصنعين من ثلاثي اليتريا وخماسي اليتريا. **الاستنتاجات**: الشيخوخة الصناعية لعينات القشرة الرقائقية يؤثر بشكل كبير على قيمة معامل الشفافية لقشرة الزركونيا الرقائقية للنوع المدمج من ثلاثي وخماسي اليتريا من الزركونيا(ZP) و ثنائي سيليكات الليثيوم فقط بسبب التكوين الجزيئي لهذه المواد .

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INTRODUCTION

Patient's demand for more natural looking restorations was increased and has led to the development of metal free materials. All ceramic restoration have High degree of translucency closer to the natural teeth which was considered as an essential element in promoting esthetics [(1)].

Zirconia materials has been rapidly revolutionized to accomplish the request for a material which combines the mechanical properties of porcelain fused to metal (PFM) materials ,esthetic and high degree of biocompatibility of the glass ceramics [(2)].

Low-temperature degradation (LTD) is one of the important phenomena related to the zirconia material due to 3% to 5%. volumetric expansion of the crystals . New generations of zirconia containing cubic phase in 50% percentage (as 5 Y-TZP) have less LTD , fracture toughness and less water corrosion due to limited residual stresses [(3)].

Translucency is mostly influenced by the size and amount of crystals and the chemical structure of the tested material[(4)] . Translucency of the natural teeth is usually increases with age, mainly in enamel[(5)]. While for all-ceramic materials such as (lithium-disilicate , glass-ceramics and leucite-based) they get more opaque on aging [(6,7)]. So many studies stated that the color of all-ceramic materials is affected by the aging process[(8,9)]. While in other studies they showed that the translucency is considered as stable and unaffected by aging [(7,10,11)].

For zirconia ceramics, according to the performed studies, translucency and color is highly affected by aging[(12,13)]. The optical properties of any material are affected by their structure[(4,14,15)]. For yttria-stabilized tetragonal zirconia material (Y-TZP), tetragonal to monoclinic transformation of the crystal structure occurs due to mechanical stress or caused by aging[(16,17)]. This transformation directly affect the translucency of the material[(12)] .

Usually, Low-temperature degradation LTD is first seen on surface layers of polycrystalline zirconia and then extended to the deepest layers of the material. The grain transformation will cause volume expansion and subsequently leads to modifications and micro-cracking of the adjacent grains. This transformation process and surface degradation is caused by water penetration and will be extended from one grain to the other and ended with increased surface roughening and compromised strength of the material due to the micro cracks and grain pullouts . LTD is associated with certain factors such as the amount of residual stresses, percent of stabilizer content and grain size , these factors will compromise the stability of tetragonal zirconia [(16)].

The purpose of this study was to evaluate the effect of aging on translucency of four different laminate veneering materials. The null hypotheses tested was that aging has no significant effect on the translucency of multilayered zirconia.

MATERIALS AND METHODS

Twenty laminate veneer from four different materials were fabricated on preformed metal dies of upper right central incisors, 5 samples for each material (E-max (control group) Zircad Prime , DD cubeX2 ML, CopraSupreme Symphony respectively)with 0.5mm thickness.

Sample preparation:

Before starting the preparation, silicone index was used to guide the preparation and for standardization of the preparation. The index was made by taking pre-preparation impression for typodonts using silicone rubber base (DUROSIL S - C Silicone Putty type 0) (heavy body). The impression was sectioned vertically to get a side view of the preparation to guide the incisal and labial reduction (incisocervically). the preparation was done in labial reduction and incisal overlap design with dimensions of (1 mm) incisal reduction , 0.5 mm labial reduction and Palatal reduction was made 1mm below the incisal edge with chamfer finishing line. The preparation ended 1mm above the cementoenamel junction (CEJ) as shown in (Figure 1). The depth of reduction was checked by using digital caliper [18].

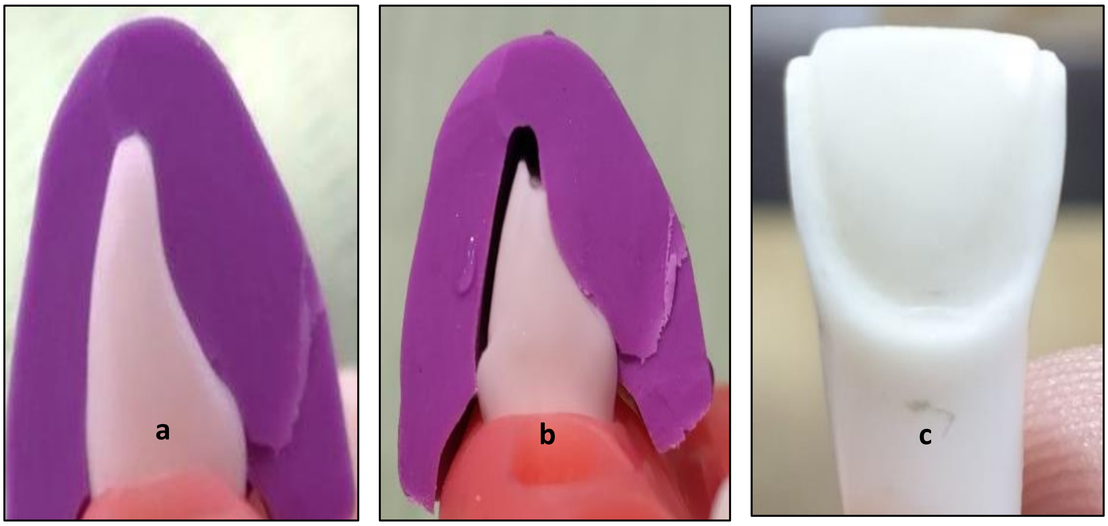

Figure (1): a:) silicone index b:) side view of the index c) Prepared typodont.

The prepared typodonts was scanned using CAD/CAM scanner to obtain a digital images which was printed into wax pattern and then processed into nickel chromium metal dies alloy, and the final laminate veneers were fabricated on the metal dies by CAD/CAM system (Figure 2).

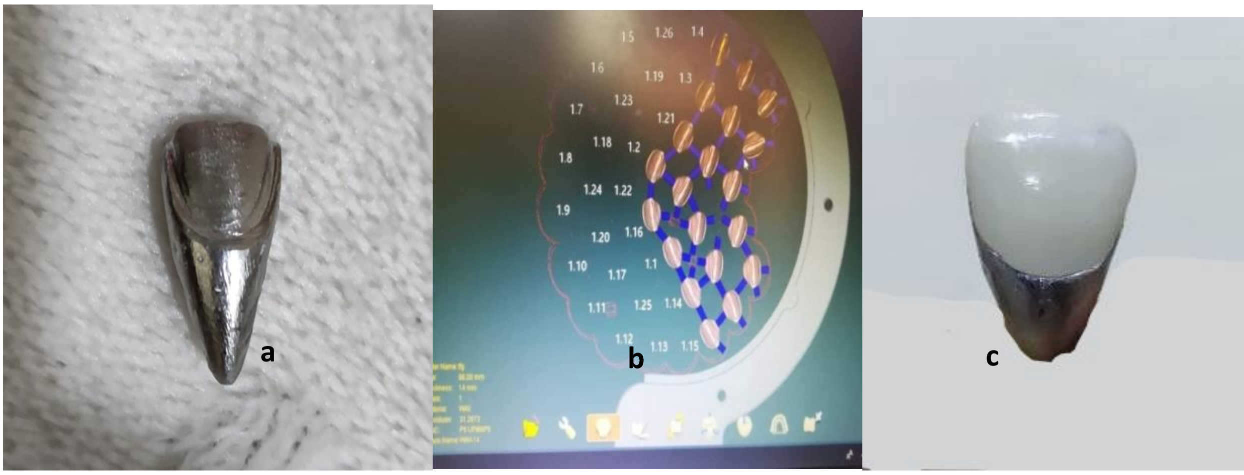

Figure (2): a)Metal die b) CAD/CAM Design of laminate veneer c) Final laminate veneer

Measurement of translucency parameter (TP) :

The color of each sample was measured using (3nh) colorimeter. Measurement was done on black and white background which were designed by painting two metal dies black and white coloring spray (Die spacer with thickness of 0.03 was used while fabricating the veneers in CAD/CAM to compensate for the thickness of the painting spray) to represent the white background and black background[19] (figure 3).

Figure (3): Black and white dies used as backgrounds.

The translucency parameter (TP) was obtained by calculating the color difference of the sample over the white and black background as follows [19]:

$TP=[(Lw^* - Lb^*)2 + (aw^* - ab^*)2 + (bw^* - bb^*)2]1/2$

Whereas :

L_b represents lightness on black background

L_w represents lightness on white background

a_b represents red–green axis on black background

a_w represents red–green axis on white background

b_b represents blue- yellow axis on black background

b_w represents blue- yellow axis on white background

Measurement was done by using positioning guide which helps to measure the same area of the samples each time (Figure 4) .

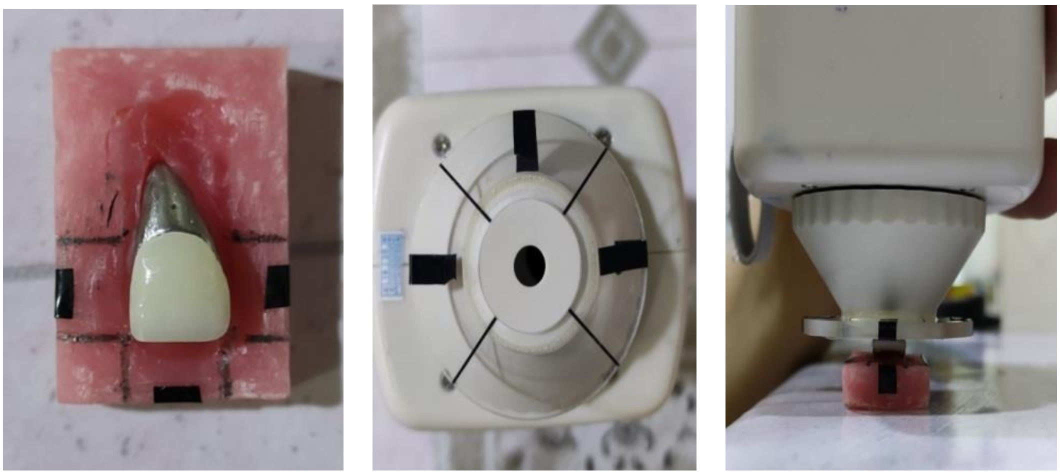

Figure (4): Alighning the positioning guide with the device while taking measurements

Artificial Aging:

Artificial aging performed according to the ISO 13356 recommendation (ISO13356, 2008). All samples were placed on dry gauze to prevent any contamination or rusting of metals on the samples and placed on the steel tray of the steam autoclave at 134°C and 0.2 MPa pressure for 5 hours (Figure 5). Aging was done on consecutive cycles and not on one continuous cycle and each cycle last for approximately half an hour which was started when the temperature reaches 134°C and the total number of the cycle was about 11 cycles. [20].

After the aging completed the samples were taken out of the autoclave and cleaned and dried to remove any debris over the surface of the samples which may affect the readings. Then measurement of TP was done again as the same way mentioned before and was compared with the results taken before aging statistically.

Figure (5): Aging of the samples

RESULTS

Artificial aging was performed and their effect on TP value of the veneered samples from different materials was analyzed using paired sample test as seen in Table (1).

Table (1) Paired samples test for the samples of four different materials.

Paired Samples test		Mean	Std. Deviation	Std. Error Mean	T	Df	Sig. (2-tailed)
E-max	before aging - after aging	1.35203	.47365	.21182	6.383	4	.003**
DD	before aging - after aging	.42719	1.18771	.53116	.804	4	.466
WP	before aging - after aging	.12190	.61623	.27559	.442	4	.681
ZP	before aging - after aging	1.07640	.85848	.38392	2.804	4	.049*

For E-max and Zircad prime (ZP) materials , Paired sample test was done and both materials showed significant different in translucency parameter (TP) value before and after aging , while for Direct Dental (DD) and White Peak (WP) materials , Paired sample test showed that there was no significant difference in translucency parameter (TP) value before and after aging as seen in Figure (6).

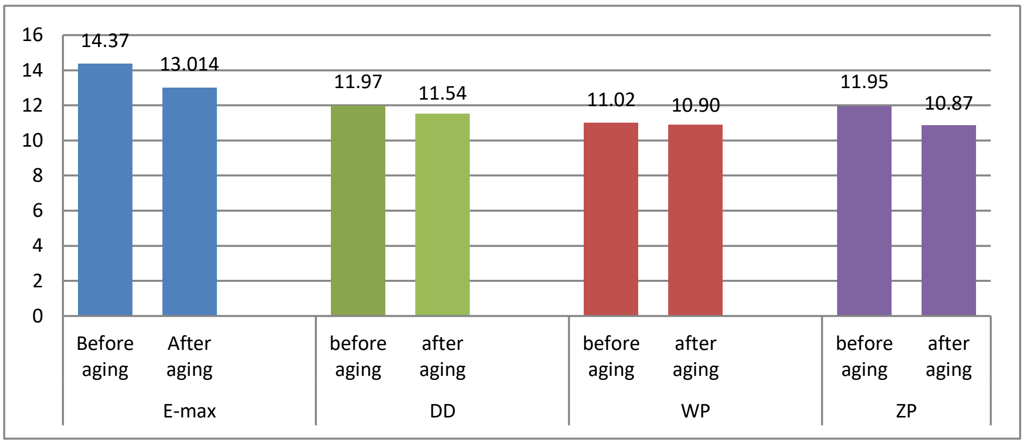

Figure (6): Column graph of paired samples Test for samples of E-max material

DISCUSSION

Low temperature degradation (LTD) or aging can be defined as the spontaneous tetragonal to monoclinic phase transformation occurring on time at low degree of temperatures, when this transformation is not stimulated by the local stress over the tip of propagating crack [23]. The main drawbacks of the transformation is the release of small zirconia grains causing roughening of the surface texture and ends with aesthetic and mechanical worsening [24] .

To date, there is no clear explanation of the mechanism of this phenomenon, only there are few speculations. The most common theories are Lange *et al*.theory (1986) based on TEM examinations, suggested that when water molecules reacts with Y_2O_3 particles it will form clusters of $Y(OH)_3$which will leads to diminish the amount of the stabilizer in the surrounding matrix of zirconia grains which will be transformed freely to monoclinic[25].

Yoshimura *et al.* (1987) proposed that water vapor will attacks the Zr–O bonds leads to break them down and causes stress concentration due to OH movement; lattice defects will be generated which will act as nucleating agents to stimulate tetragonal to monoclinic phase (*t*–*m*) transformation[26]. Chevalier *et al*. (2009) stated that the originated O_2 from water dissociation and not OH is the one responsible for the occupation of oxygen vacancies and the subsequent destabilization and degradation[27].Irrespective of the mechanism, it is well known that *t*–*m* transformation begins on the surface and proceeds inward and it produces surface uplift [28], micro cracks and subsequently aesthetic degradation [23].Furthermore , it opens the way for the water to penetrate under the surface, and thus propagating the transformation to the inner part of the sample [29] and causes major cracks development [27].All these detrimental events will negatively affects the structure of Y-TZP.

Aging phenomena had affected significantly the TP value of the laminate veneers made from E-max and ZP (14.37 , 11.95 before aging respectively) compared to (13.01 and 10.87 after aging respectively) as shown in Tables (1) and Figures (6) . For zirconia materials the difference is related to difference in the composition and the variable degree in the tetragonal to the monoclinic transformation in the combined type of zirconia material which is responsible for the changes in light reflection of the monoclinic crystals themselves and also at the monoclinic and tetragonal boundaries . Moreover, due to the associated with the , more surface porosity will be created which will influence the translucency [30]. For ZP and DD they showed no significant effect by aging due to their homogenous structural composition with uniform rate of transformation and volumetric change [31]. The results of this study agreed with these in Abdelbary *et al*(2016) and Alghazzawi (2016) [32,33]. While for lithium disilicate the change in color is due the increased thickness which means more grains content and this leads to increased size of the particle and thus more rough and irregular surface and more surface penetration of discoloring agents and more network disintegration [23].

CONCLUSION

Artificial aging has pronounced effect on E-Max and ZP zirconia ceramic materials while DD and WP were not significantly affected by aging .

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