The Effect of Artificial Accelerated Aging on The Color of Ceramic Veneers Cemented With Different Resin Cements (A Comparative In Vitro Study)

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ABSTRACT

Background: Color changes that are detectable to human eye can affect the esthetic appearance of ceramic veneers. The purpose of this study was to evaluate and compare the effect of artificial accelerated aging on the color of ceramic veneers cemented with different resin cements.

Materials and Methods: Sixty discs were prepared with 0.5 mm thickness, 30 discs made from IPS e.max press (Ivoclar Vivadent) and 30 discs were made from VITA Enamic (VITA Zahnfabrik). The discs were cemented with three resin cements: Variolink Veneer MV 0 shade (Ivoclar Vivadent), Rely X veneer Translucent shade (3M ESPE) and NX3 Nexus Clear shade (Kerr Corporation) with 0.1 mm thickness. The spectrophotometer Easyshade Advance was used to measure the color parameters (Lightness, axis a* of chroma and axis b*of chroma) immediately after cementation, after 150 and 300 hours of aging. The specimens were subjected to artificial accelerated aging in Accelerated Weathering Tester. Color change greater than 3.3 was considered unacceptable. One-way ANOVA, paired t-tests and Bonferroni adjusted t-test were used for statistical analysis ($p < 0.05$).

Results: Artificial aging caused high significant color change in both ceramic types, but there were non-significant difference in color change among the three resin cements used. The color change was between1.997-14.8 after 150 hours and it was between 2.179-15.68 after 300 hours. The color change of e.max discs after aging were within acceptable limit<3.3 whereas Vita Enamic specimens had shown unacceptable color change >3.3 after aging.

Conclusions: The majority of color change after aging related to veneering materials while resin cement have only slight effect on color change after aging. IPS e.max had shown an acceptable color change after aging, so it is suitable for fabrication of restorations in esthetic zone while Vita Enamic should not be used in esthetic zone since it has poor color stability according to the results of this study.

Keywords: Ceramic veneers, artificial accelerated aging, spectrophotometer, color stability. **(J Bagh Coll Dentistry 2017; 29(1):39-46)**

INTRODUCTION

Ceramic veneer have been a popular treatment option of anterior teeth especially for patients who looking for conservative and best esthetic treatment since these restorations require minimum reduction of tooth structure when compared with another restorations [1].

One of major concern in dentistry is to obtain the perfect color that resembles the color of natural teeth with artificial materials [2].

Ceramic restorations are one of most important restorations that can achieve light scattering and transmission that are resemble the appearance of natural teeth [3]. Assessment of the color of both teeth and restorations accurately is critical for effective communication with dental laboratory and for successful clinical outcome

The color assessments that performed with visual techniques are subjective and to eliminate the subjectivity of human eye electronic intraoral devices such as colorimeter and spectrophotometer were introduced. These electronic devices measure the color of restorations using Commission Internationale de l'Eclairage (International Commission on Illumination) CIE L*a*b* color system [4]. The increased concern on esthetic appearance in today's society had led to consider the color stability of esthetic restoration as critical factor for long-term success of such restorations [5]. The color stability is an important factor for direct and indirect esthetic restoration and is a fundamental to the success of the restorative treatment [6]. The difference in the color determined whether the color change can be noticeable by human eye since $\Delta E<1$ is not detectable by human eye and ΔE greater than 1 and less than 3.3 considered noticeable but clinically acceptable while $\Delta E>3.3$ considered clinically unacceptable [7]. In order to evaluate the long-term color stability of cemented veneer the artificial

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accelerated aging was used. To simulate the conditions to which the restorations will exposed in the oral cavity for a relatively long time the accelerated aging that use ultraviolet light, humidity and temperature is most commonly used [8]. The aim of this in vitro study was to evaluate and compare the effect of artificial accelerated aging (ultraviolet light, humidity and temperature) on the color of ceramic veneers which made from IPS e max press and VITA Enamic and cemented with three different resin cements.

MATERIALS AND METHODS

A total of sixty discs that have a diameter of 10 mm and 0.5 mm thickness were prepared. Thirty discs were made from (IPS e max press, HT A1 shade, Ivoclar Vivadent) and thirty discs were made from (VITA Enamic blocks, HT 1M1 shade, VITA Zahnfabrik). The specimens that made from e max were fabricated by using of hot pressing technique according to the manufacturer instructions. The discs were finished with DCB grinder cone (Komet Brasseler, USA) then a single layer of IPS ceram glaze were applied on one surface of the discs [8]. The specimens that made from VITA Enamic blocks were prepared by using custom made milling machine which milled the blocks into cylinders then cut the cylinders into the discs with the desired dimensions. The discs made from VITA Enamic were glazed with VITA Enamic glaze which is a light cure glazing material, and it required treatment of each disc with 5% hydrofluoric acid, the etched surface were silanated with Monobond N for 60 second after that a single layer of VITA Enamic glaze was applied and light cured according to manufacturer instructions. All of the 60 discs were ultrasonically cleaned in distilled water for 10 minutes before and after glazing then digital caliper was used to make sure that all the discs have 10 mm diameter and 0.5 mm thickness [9]. Then the e max discs were divided into 3 groups (A1, A2, A3) and VITA Enamic discs divided into 3 groups (B1, B2, B3):

A1: 10 discs of IPS e max cemented with Variolink Veneer resin cement

A2: 10 discs of IPS e max cemented with RelyX veneer resin cement

A3: 10 discs of IPS e max cemented with NX3 Nexus resin cement

B1: 10 discs of VITA Enamic cemented with Variolink Veneer resin cement

B2: 10 discs of VITA Enamic cemented with RelyX veneer resin cement

B3:10 discs of VITA Enamic cemented with NX3 Nexus resin cement

For cementation unglazed surface of all discs were etched with 5% hydrofluoric acid (IPS Ceramic refill, Ivoclar Vivadent), e max discs were etched for 20 secconds while VITA Enamic discs were etched for 60 seconds. Then the discs were rinsed with water spray for 30 seconds and dried [10]. Afterward the discs of group A and group B were silanated with Monobond N (Ivoclar/Vivadent /clinical, Lienchtenstein) which was dispensed on the etched surface of the discs with microbrush for 60 seconds then lightly dried for 5 seconds to evaporate the solvent according to manufacturer instruction. Three light cured resin cements were used which are Variolink Veneer (Ivoclar/Vivadent /clinical, Lienchtenstein) that have medium value 0 shade, RelyX veneer translucent shade (3M ESPE, USA) and NX3 Nexus light cure which have clear shade (Kerr Corporation, USA). The discs were placed on glass slide then the resin cements were applied from the syringe directly on the silanated surface of discs [9]. Afterward the Mylar strip was placed over the cement [11, 12] then another glass slide was placed over the strip. Weight of 1Kg was applied over the glass slide for 20 seconds to produce a thickness of resin cement that is equal to 0.1 mm [9, 13]. To simulate the clinical condition the cements were light cured from the glazed surface. To remove the excess of the cement the discs were tack-cured for 1-3 seconds to convert the excess into a gel state then the excess gel was removed with dental probe. Then cement was completely light cured according to manufacturer instruction (For Variolink veneer 30 seconds, for RelyX veneer 30 seconds and for NX3 Nexus 20 seconds). Digital caliper was used after cementation to ensure that the thickness of all specimens were 0.6 mm [8].

Color measurement was made by using of Easyshade advance (Vita Zahnfabrik, Bad Sackingen, Germany) which consist of base unit and handpiece [14]. During color measurement the discs were placed on polywax (BiLKiM Co.LTD, Turkey) that had the shade of A3. This polywax was used to simulate the underlying dental tissues [15]. The single tooth mode was selected then the spectrophotometer was calibrated according to manufacturer instruction. The probe of the device was placed in the center of the disc and perpendicular to the disc and the button of the device was pressed and the shade appeared in both Vita Classical and Vita 3D master shades and the

color parameter (Hue, chroma, lightness L*, a* and b*) displayed on the screen of the device [16, 17]. Three measurements were made for each disc while the probe of the device was in the center of the disc and the mean of the three measurements was calculated as initial color of the disc and used for data analysis [9, 12, 17].

The specimens were undergoing accelerated aging test using Accelerated weathering tester (QUV/SPRAY) (Q-Lab Corporation, USA). The specimens were placed in custom made aluminum holders; these holders have the same dimension of the specimens (10 mm diameter and 0.5 mm depth). Then the holders were attached to accelerated weathering tester in which only the glazed surface of the discs were exposed to artificial accelerated aging and the specimens stored in the device for 300 hours. In accelerated weathering tester the specimens were subjected to 150 cycles of aging each cycle was two hours long. Within each cycle the specimens were exposed to ultraviolet light for 1 hour and 42 minutes and distilled water spray for 18 minutes and the temperature was 50ºC [18]. According to the manufacturer of the accelerated weathering tester the 300 hours of aging is equivalent to one year in clinical service [19].

After the passage of 150 hours during which the specimens were inside the accelerated weathering tester, color parameters of the specimens were measured again. The discs were also placed on polywax and Easyshade Advance was used to measure the color of specimens after 150 hours of aging. The 150 hours in accelerated weathering tester is equal to 6 months intraorally [20]. The color difference ΔE calculated from L*, a*, b* before and after aging for 150 hours using the following equation:

$$\Delta E = [(\Delta L)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where ΔE represent color difference, ΔL, Δa and Δb are the difference in color parameters of the specimens before and after aging [21].

At the end of aging period (300 hours) the color parameters of the specimens were measured again and the color difference were obtained from the same equation. The results of this study were analyzed with one-way ANOVA, paired t-tests and Bonferroni adjusted t-test ($P < 0.05$).

RESULTS

At the baseline ANOVA test revealed high significant difference in lightness (P=0.002) and axis a* of chroma (P <0.001) among the three resin cements when used with e max, while the same test show high significant difference among the three cements when used with Vita Enamic only in axis a* of chroma (P<0.001) at the baseline. Bonferroni adjusted t-test showed statistically significant differences in mean chromaticity (axis a* and axis b*) between e max and VITA Enamic in each cement group at the baseline.

The mean and standard deviation of color change after 150 hours and 300 hours of aging are shown in (Table1). The results of this study revealed that after 150 hours of aging the highest color change was found in group B1 (14.8 ±1.873) and the least color change recorded in group A3 (1.997± 0.503), also after 300 hours of aging group B1 recorded the highest color change (15.68±1.748) and the least color change was (2.179±0.482) which is found in group A3.

The results of Paired t-test had shown that there were statistically highly significant difference in color change after 150 hours and after 300 hours of aging in the six groups (P<0.001), also the color difference between the two periods of aging was statistically high significant (Table 1).

Within group A and after 150 hours and 300 hours of aging the use of Variolink Veneer with e max (A1) was associated with the highest mean of color change, followed by RelyX veneer with e max (A2) and the least color change was found when NX3 Nexus was used with e max (A3). Bonferroni adjusted t-test had shown that the difference in the effect of the three resin cements on the mean color change after aging was statistically not significant. Within group B and after 150 hours and 300 hours of aging the use of Variolink Veneer with VITA Enamic (B1) recorded the highest mean of color change, followed by RelyX veneer with VITA Enamic (B2) and the least color change recorded in (B3) in which NX3 Nexus was used with VITA Enamic. Bonferroni adjusted t-test had shown that the difference in the effect of the three resin cements on mean color change after aging was statistically not significant.

Table 1: Range, Mean, standard deviation, standard error and P (Paired t-test) of color change after 150 hours, 300 hours of aging and color difference between 300 hours and 150 hours of aging.

	ΔE after 150h of aging	ΔE after 300h of aging	ΔE between 300h and 150h of aging
A1			
Range	(1.261 to 4.943)	(1.473 to 5.288)	(0.225 to 0.381)
Mean	3.017	3.262	0.302
SD	1.053	1.079	0.062
SE	0.333	0.3413	0.0196
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001
A2			
Range	(1.465 to 3.467)	(1.626 to 3.628)	(0.111 to 0.525)
Mean	2.501	2.715	0.283
SD	0.685	0.655	0.111
SE	0.2166	0.2073	0.0352
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001
A3			
Range	(1.491 to 2.921)	(1.717 to 3.048)	(0.125 to 0.436)
Mean	1.997	2.179	0.253
SD	0.503	0.482	0.092
SE	0.1591	0.1524	0.0292
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001
B1			
Range	(12.907 to 18.484)	(13.646 to 19.043)	(0.645 to 1.806)
Mean	14.8	15.68	1.17
SD	1.873	1.748	0.29
SE	0.5924	0.5527	0.0916
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001
B2			
Range	(12.429 to 16.252)	(12.028 to 18.059)	(0.454 to 1.369)
Mean	14.668	15.437	0.95
SD	1.225	1.632	0.289
SE	0.3875	0.516	0.0915
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001
B3			
Range	(11.872 to 15.926)	(12.96 to 16.717)	(0.446 to 1.109)
Mean	14.159	14.813	0.822
SD	1.174	1.095	0.231
SE	0.3713	0.3462	0.0732
N	10	10	10
P(Paired t-test)	<0.001	<0.001	<0.001

When Comparing the mean color difference between group A and group B (e max and VITA Enamic) in the same type of cement after the two periods of aging the use of e max associated with the least color change and Bonferroni adjusted t-test revealed that there were statistically significant

difference in mean color change between e max and VITA Enamic in each cement type.

In spite of that color change of group A1, A2 and A3 after the two periods of aging was statistically significant, the color changes of these groups are considered detectable but clinically acceptable since the color changes in these groups less than 3.3.

DISCUSSION

In this study the specimens were prepared from IPS e max press and Vita Enamic blocks. IPS e max press which is lithium disilicate glass ceramic was used because of its unique properties and it had been used most frequently in fabrication of veneers in recent years [22]. VITA Enamic was selected for this study due to its hybrid structure which composed of interpenetrating two networks. These interpenetrating networks consist of ceramic which is porous and polymer which infiltrated within the ceramic, that make the material have the advantages of ceramic and composite [23, 24]. The specimens thickness of 0.5 mm was selected to evaluate the effect of artificial accelerated aging on the color of cemented veneers because veneers are conservative restoration and the preparation should be within the enamel to ensure optimal bonding of the veneers to tooth structure, so the recommended preparation for veneers 0.5-0.7 mm [9, 25]. In this study the color stability of resin cements that are covered by ceramic and isolated from the surrounding environment was evaluated to simulate the clinical condition[9].

In order to simulate the condition in the oral cavity for a relatively long service time artificial accelerated aging was used. Accelerated aging test permit the determination of color change that occurred in restorative materials over time [7]. In accelerated aging device the restorative materials exposed to ultraviolet light, changes in temperature and humidity in an attempt to simulate the oral environment as closely as possible [26]. According to the manufacturer of the accelerated aging device 300 hours is equal to one year inside the patient mouth and most of color change that occurred in restorative materials developed in the first 100 hours [27]. At the baseline ANOVA test revealed high significant difference in lightness (P=0.002) and axis a * of chroma (P<0.001) among the three resin cements when used with e max, while the same test showed highly significant difference among the three cements when used with Vita Enamic only in axis a* of chroma, these differences in (L* ,a*,b*) values among the three cements in both groups (e max and VITA Enamic) could be due to difference in the number and size of filler of resin cement as the color of composite materials affected by the filler particle size and number [8,28].

At the baseline there was statistically significant difference in the mean of both axis of chromaticity (a* and b*) between Vita Enamic and e max in each cement and this could be due to that the materials from different brands may have the same shade but have differences in color parameters and this in agreement with Chang et al [29] who found that resin cements from different companies which have the same shades show differences in L*, a*, b* values. After 150 hours of aging, all groups had shown statistically high significant differences in mean color changes. Within group A, A1 showed the highest mean color change (3.017±1.053) while A3 showed the least color difference (1.997±0.503). However these difference in mean color change among the three cements was statistically non-significant and this in agreement with Turgut and Bagis [9] who had study the color stability of veneers made from different shades of e max and cemented with resin cements from different brands and different shades and they found that high translucent shade of e max with medium value of Variolink Veneer show more color change after aging than high translucent shade of e max with translucent shade of RelyX veneer. These differences in color change among the three groups (A1, A2, A3) may be attributed to difference in composition of the three resin cements and the affinity of their resin matrix to absorb water since the resin matrix considered as the source of discoloration so the higher fraction of resin matrix per volume the higher color change will result [30, 31]. Within group B, the differences in mean color change among the three resin cements was not significant and B1 had shown the highest mean color change (14.8±1.873) and B3 had shown the least color change after aging (14.159±1.174). In both groups (A, B) the use of Variolink Veneer resin cement is associated with the highest mean of color change, while NX3 Nexus show the least mean of color difference. Variolink Veneer showed the highest mean of color difference may be due to its filler load per volume is the least when compared with the other two cements (Variolink 40%vol., Rely X 47%vol., NX3 Nexus 47.7%vol.). Variolink have more resin matrix than the two other cements, so it associated with the greater

water sorption which is responsible for color change [32-34].

VITA Enamic had shown higher color change than IPS e max when used with the same cement. VITA Enamic had shown very high color change after exposure to artificial accelerated aging may be due to the presence of polymer which comprised 25% of its volume. This polymer composed of Urethane dimethacrylate (UDMA) and triethylene glycol dimethacrylate (TEGDMA). UDMA have very low water sorption so it is associated with less color change. However, TEGDMA is very hydrophilic and increase the hydrophilicity of the surface that results in an increase in water sorption which leads to color change. TEGDMA increase water sorption due to ether linkages which is hydrophilic [35-38]. VITA Enamic had shown color instability after 150 hours and require replacement and this disagree with the manufacturer claim that the material is color stable and with Dirxen et al [24] who had tested VITA Enamic crowns in patient mouth for two weeks and found that the crowns weren't show any color change. The color change of IPS e max may resulted from the metal oxide which added to ceramic to obtain the color shades and under the ultraviolet light these metal oxides are very easily break down and peroxides compound may developed and result in color change [27]. The difference in the color between the color of the materials after 300 hours of aging and the color of the materials after 150 hours of aging had shown statistically significant difference, however these color changes were very small and clinically unnoticeable by human eye. When comparing the color difference in the first 150 hours and the second 150 hours of aging, most of color change occur in the first period and in the second period there was slight color change and this in agreement with Cao et al [39] and Ghavam et al [40] who were stated that most color difference occur in the first 100 hours of aging. Cao et al have been studied the effect of accelerated aging on the color stability of alumina-based and leucite –based ceramics and found that the first 100 hours of aging produced the major color change, while Ghavam et al had studied the effect of accelerated aging on color stability of resin cements and concluded that the majority of color change occur in the first 100 hours of aging.

After the passage of the half of artificial aging periods (150 h) and also at the end of aging period (300 h) the percentage of Vita Enamic specimens that show color change > 3.3 was 100%, while the percentage of e max specimens which had color change >3.3 after 150 h was 16.7% and their percentage after 300 h was 20%. In spite of that the color change within groups A1, A2, A3 was statistically significant after 150 hours and 300 hours of aging, but the color change within these groups remain within the acceptable color change clinically and this in agreement with Turgut and Bagis [9] who had study the color stability of veneers fabricated from different shades of IPS e max press cemented with different shades of different resin cements.

CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions were found:

1. Both restorative materials (IPS e max Press and VITA Enamic) used in this study had shown significant color change after accelerated aging.
2. IPS e max Press showed color change after aging that can be considered acceptable clinically because color difference was below 3.3 units, so this material is suitable to be used for fabrication of restorations in esthetic zone.
3. VITA Enamic after aging showed color change that considered unacceptable clinically and this material should be avoided in fabrication of restorations in esthetic zone.
4. There was no significant difference in the effect of the three different resin cements used in the study on color change after aging process, but NX3 Nexus may considered the best for luting veneers since it is associated with the least color change after aging.
5. The majority of color change after accelerated aging related to change in the color of veneering materials rather than luting cements.
6. Most of the color change of veneering materials appears in the first 150 hours (6 months) of aging.

REFRENCES

1. Dozic A, Tsagkari M, Khashayar G, Aboushelib M. Color management of porcelain veneers: influence of dentin and resin cement colors. Quintessence international 2010; 41(7):567-573
2. Vichi A, Ferrari M, Davidson CL. Color and opacity variations in three different resin-based composite products after water aging. Dent Mater 2004; 20(6):530-534.
3. Niu E, Agustin M, Douglas RD. Color match of machinable lithium disilicate ceramics: Effects of cement color and thickness. The Journal of Prosthetic Dentistry 2014; 111(1):42-50.
4. Charisis D, Koutayas SO, Kamposiora P, Doukoudakis A. Spectrophotometric evaluation of the influence of different backgrounds on the color of glass-infiltrated

ceramic veneer. The European journal of esthetic dentistry 2006; 1(2):142-156.
5. Magalhaes AR, Siqueira PC, Cardoso PC, Souza JB, Fonseca RB, Pires Souza FCP, Lopes LG. Influence of the resin cement color on the shade of the porcelain veneers after artificial accelerated aging. Rev Odontol Bras Central 2013; 21(60):11-15.
6. Dos Santos PH, De Souza FI, Guedes APA, Pavan S. Effect of post polymerization method on the color stability of composite resins submitted to ultraviolet aging. The international journal of periodontics and restorative dentistry 2012; 32(3):e95-e100.
7. Pires De Souza, Casemiro LA, Garcia LFR, Curvinel DR. Color stability of dental ceramics submitted to artificial accelerated aging after repeated firings. Journal of prosthetic dentistry2009; 101(1):13-18.
8. Turgut S, Bagis B, Turkaslsn SS, Bagis Y H. Effect of Ultraviolet Aging on Translucency of Resin-Cemented Ceramic Veneers: An In Vitro Study.Journal of prosthodontics 2014;23(1):39-44.
9. Turgut S, Bagis B. Color stability of laminated veneers: An in vitro study. Journal of dentistry 2011; 39(suppl3):e57- e64.
10. Khatib D, Katamish H, Ibrahim AS. Fracture load of two CAD/CAM ceramic veneers with different preparation designs .Cairo dental Journal2009; 25(3):425-432.
11. DE-Souza FCP, Garcia LFR, Hamida HM, Casemiro LA. Color Stability of Composites Subjected to Accelerated Aging after Curing Using Either a Halogen or a Light Emitting Diode Source. Braz Dent J 2007; 18(2):119-123.
12. Sarkis E. Color change of some aesthetic dental materials: Effect of immersion solutions and finishing of their surfaces. The Saudi dental journal2012; 24:85-89.
13. Hekimoglu C, Anil N, Etikan I. Effect of accelerated aging on the color stability of cemented laminate veneers. The international Journal of Prosthodontics2000; 13(1):29-33.
14. Corcioloni G. A study of dental color matching, color selection and color reproduction. A Phd thesis, Biotechnologies: section of biomaterials, University of Sienna, 2009.
15. Cubas G B A, Camacho GB, Demarco FF, Cenci TP.The Effect of Luting Agents and Ceramic Thickness on the Color Variation of Different Ceramics against a Chromatic Background. European Journal of Dentistry 2011; 5:245-252.
16. Nogueira AD, Della Bona A. The effect of a coupling medium on color and translucency of CAD–CAM ceramics. Journal of dentistry 2013; 41(suppl3):e18-e23.
17. Yilmas SK, Ulusoy M. Comparison of the translucency of shaded zirconia all-ceramic systems. J Adv prosthodont 2014;6: 415-422.
18. Ramoglu SI, Usumez S, Buyukyilmaz T. Accelerated Aging Effects on Surface Hardness and Roughness of Lingual Retainer Adhesives. Angle Orthodontist 2008; 78(number1):140-144.
19. Ergun G, Nagas IC. Color stability of silicon or acrylic denture liners: an in vitro investigation .European journal of dentistry 2007; 1:140-151.
20. Anil N, Hekimoglu C, Büyükbas N, Ercan MT. Microleakage study of various soft denture liners by autoradiography: effect of accelerated aging. J Prosthet Dent. 2000; 84(4):394–399.
21. Xing W, Jiang T, Ma X, Liang S, Wang Z, Sa Y, Wang Y. Evaluation of the esthetic effect of resin cements and try-in pastes on ceromer veneers. J Dent. 2010; 38 Suppl 2: e87-e94.
22. Tysowsky G. The Science behind Lithium Disilicate: Today's Surprisingly Versatile, Esthetic & Durable Metal-Free Alternative. Oral health journal 2009. Available from: http://www.oralhealthgroup.com/news/the-science-behind-lithium-disilicate-today-s-surprisingly-versatile-esthetic--durable-metal-free-al/1000229938/?&er=NA
23. He LH, Swain M. A novel polymer infiltrated ceramic dental material. Dental materials 2011; 27(6):527-534.
24. Dirxen C, Blunck U, Preissner S. Clinical Performance of a New Biomimetic Double Network Material. Open Dent J. 2013; 7: 118–122.
25. Chen XD, Hong G, Xing WZ, Wang YI. The influence of resin cements on the final color of ceramic veneers. Journal of prosthodontics research 2015; 59(3):172-177.
26. Heydecke G, Zhang F, Razzoog ME. In vitro color stability of double-layer veneers after accelerated aging. J Prosthet Dent 2001; 85(6):551-557.
27. Ertan AA, Sahin E. Colour stability of low fusing porcelains: an in vitro study. J Oral Rehabil 2005; 32:358-361.
28. Buchalla W, Attin T, Hilgers RD, Hellwig E. The effect of water storage and light exposure on the color and translucency of a hybrid and a microfilled composite. J Prosthet Dent 2002; 87(3):264-270.
29. Chang J, Da Silva JD, Sakai M, Kristiansen J, Ishikawa-Nagai S. The optical effect of composite luting cement on all ceramic crowns. Journal of dentistry 2009; 37:937–943
30. Vichi A, Ferrari M, Davidson CL. Color and opacity variations in three different resin-based composite products after water aging. Dent Mater 2004; 20(6):530-534.
31. Ertas E, Guler AU, Yucel AC, Korpulu H,Guler E. Color Stability of Resin Composites after Immersion in Different Drinks. Dental Materials Journal 2006, 25(2):371-376.
32. Schulze KA, Marshalla SJ, Ganskyb SA, Marshall GW. Color stability and hardness in dental composites after accelerated aging. Dental Materials 2003; 19: 612–619.
33. Ozel E, Ozturk E, Taskinsel E. Effects of sports beverages and polishing systems on color stability of different resin composites. Journal of Conservative Dentistry2014; 17(4):325-329.
34. Naumi HO, Ragab HM. Effect of aggressive beverage on the color stability of different nano-hybrid resin based composite. Eur J Gen Dent 2014; 3(3):190-193.
35. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dental Materials 2006; 22: 211–222.
36. Topcu FT, Sahinkesen G, Erdemir U, Oktay EA, Ersahan S. Influence of Different Drinks on the Colour Stability of Dental Resin Composites. European Journal of Dentistry 2009; 3: 51-56.
37. Abd Alhadi N, Jabbar AM, Kadhim AJ. Effect of 38% hydrogen peroxide agent on color change of composite resins stained with tea and coffee beverages (An in vitro study). MDJ2012; 9(2):149-158.

38. Kaleem M, Khan AS, Rehman IU, Wong FS. Effect of Beverages on Viscoelastic Properties of Resin-Based Dental Composites. Materials 2015; 8(6):2863-2872.
39. Cao J, He H, Wang Z. Color stability against accelerated aging of alumina- and leucite –based ceramic materials.Int Chin J Dent 2007;7:49-52.
40. Ghavam M, Amani-Tehran M, Saffarpour M. Effect of Accelerated Aging on the Color and Opacity of Resin Cements. Operative dentistry 2010; 35(6); 605-609.

الخلاصة

تغير اللون الذي يمكن تمييزه من قبل العين البشرية يمكن ان يؤثر على المظهر الجمالي للقشور الخزفية. الغرض من هذه الدراسة كان لتقييم ومقارنة تأثير التعتيق الصناعي المعجل على لون القشور الخزفية المثبتة باستخدام انواع مختلفة من الاسمنت الراتنجي. تم اعداد ستون قرص ذات سمك 0.5 ملم, ثلاثون قرص(المجموعة أ) صنعت من (IPS e max Press,Ivoclar Vivadent)والثلاثون قرص الاخرى (المجموعة ب) صنعت من (VITA Enamic ,VITA Zahnfabrik). ثلاثة انواع من الاسمنت الراتنجي استخدمت وبسمك0.1 ملم [(Variolink Veneer, Ivoclar Vivadent),(RelyX veneer, 3M ESPE),(NX3 (Nexus, Kerr Corporation)] استخدم المطياف (Easyshade Advance) لقياس ابعاد اللون (سطوع اللون والمحور أ وب من كثافة اللون) بعد اضافة الاسمنت الراتنجي للاقراص وبعد مرور150ساعة و300 ساعة من التعتيق. تم تعريض العينات للتعتيق الصناعي المعجل في جهاز التجوية (accelerated weathering tester) لمدة 300 ساعة. تم اعتبار تغير اللون الاكبر من 3.3 غير مقبول في هذه الدراسة. تم تحليل النتائج احصائيا باستخدام اختبار (ANOVA), اختبار الاقتران (Paired t-test) و اختبار (Bonferroni adjusted t-test) عند مستوى معنوي اصغر من 0.05. اظهرت النتائج ان التعتيق الصناعي قد تسبب بتغير مهم للون كلا نوعي السيراميك المستخدمين في الدراسة, ولكن لم يكن هناك فرق كبير في تغير اللون بين الثلاثة انواع من الاسمنت الراتنجي المستخدمة. الاقراص المصنوعة من (IPS e max press) قد اظهرت تغير في اللون اقل من 3.3 والذي يعتبر تغير مقبول, ولكن الاقراص المصنوعة من (VITA Enamic) اظهرت تغير غير مقبول في اللون. وفقا لنتائج هذه الدراسة يمكن ان نستنتج بأن الغالبية العظمى من تغير اللون بعد التعتيق كان بسبب مادة القشور الخزفية المستخدمة وان الاسمنت الراتنجي بعد التعتيق لم يكن له اثر كبير على تغير اللون. بعد التعتيق. اظهرت مادة (IPS e max) تغير مقبول في اللون لذلك هي مناسبة لترميم الاسنان ضمن المنطقة الجمالية في حين مادة (VITA Enamic) لا ينبغي ان تستخدم في ترميم الاسنان ضمن المنطقة الجمالية لأنها اظهرت ضعف في ثبات اللون بعد التعتيق