Influence of the Resin Cement Color on the Shade of Porcelain Veneers After Accelerated Artificial Aging

Influência da Cor do Cimento Resinoso na Tonalidade de Facetas de Porcelana Após Envelhecimento Artificial Acelerado

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ABSTRACT

Objectives: The aim of this study was to evaluate the influence of the color of the resin luting cement in the final shade of minimally invasive porcelain veneers after accelerated artificial aging (AAA). Material and methods: 20 bovine teeth were collected, prepared and divided into two groups. The roots were removed and the buccal surfaces were polished to obtain a flat surface. Porcelain discs (IPS Empress Esthetic) were produced to a standardized shade (ET1) and thickness (0.6mm). The teeth and the veneers surfaces were prepared according to manufacturer recommendations. For group I (n=10), the White-Opaque (WO) base-paste was used and for group II (n=10) the Yellow (Y) base-paste. Each specimen was photocured for 60 s. The specimens were next subjected to AAA. They were submitted to color readings with a spectrophotometer in three moments: after the preparation (only the substrate), after the cementation and polymerization of the veneers and after the AAA. Were obtained values of L*, a* and b* and the total color change was calculated (ΔE*). Values obtained were subjected to statistical analysis in SPSS 17.0 for Windows with a significance of 0.05. Results: When comparing the cements, the Y cement showed higher ΔE*, lower L* and higher b* after AAA than the WO. Conclusion: Both cements could mask the substrate color. With AAA, only the Y shade showed a ΔE* clinically unacceptable, becoming more yellow (higher b*) and losing lightness (lower L*).

KEYWORDS: Dental veneers, resin cements, aging, color perception tests.

INTRODUCTION

Several recent advances in dental bonding technology and resin cements have led to the evaluation of successful, permanently cemented porcelain laminate veneers (PLV)[1-4]. Currently, there are many commercially available ceramic materials reinforced with leucite, lithium dissilicate, aluminum oxide, and zirconium dioxide, which can be used to produce minimally invasive restorations[2,5,6]. This technique made possible to produce PLVs with thicknesses ranging from 0.1 to 0.7mm requiring minimum or no preparation of the tooth structure[5].

Resin cements are generally used for the cementation of all-ceramic restorations since they provide adequate aesthetics, low solubility in oral environment, high bond strength to tooth structures, superior mechanical properties and support for ceramics[7,8,9]. Resin cements are produced by several manufacturers and in various polymerization types and shades[9-11]. The different shade options for luting cements may affect the final result of the PLVs specially the high translucency ceramics[12,13].

With the great emphasis placed on esthetics by today's society, the color stability of esthetic restorative materials gains critical importance[1]. Artificial accelerated aging (AAA) submits the samples to increased temperature, humidity and ultraviolet light[5,14-16]. These conditions can induce an oxidation process of the amine, component used as initiator of resin cements, leading to color changes[5,14]. Studies conducted under accelerated aging conditions allow one to predict the physical behavior of dental composites over time, including color changes[1,14,17-22].

Considering the importance of the color stability of a PLV for its long term success, the aim of this study was to evaluate the influence of the color of a resin luting cement in the final shade of minimally invasive porcelain veneers after accelerated artificial aging.

MATERIAL AND METHODS

Twenty bovine teeth were collected, prepared and randomly divided into two groups. The teeth have been stored in Thymol solution, the roots were removed and the buccal surface was polished using fine abrasive paper to make it as flat as possible for the cementation of the laminates.

Porcelain discs (IPS Empress Esthetic, Ivoclar Vivadent, Leichtesntein, Germany) were produced to a standardized shade (ET1) and thickness (0.6 mm). This shade was selected because it is a light shade, and the most used shades in PLV fabrication. The resin cement used in this study was Variolink II (Ivoclar Vivadent) - base pastes in the colors White-Opaque (WO) and Yellow (Y).

Before the cementation, the teeth were cleaned with pumice and water. Then the surfaces were etched using 37% phosphoric acid (Total Etch, Ivoclar Vivadent) for 15–20 s as instructed by the manufacturer. After washing thoroughly with water for 10 s and drying, the adhesive Excite F (Ivoclar Vivadent) was gently applied for 10 s, dried with light air spray and photocured for 20 s. The veneers were etched with 10% hydrofluoric acid for 20s, and then washed with water. Silane (Monobond-S, Ivoclar Vivadent) was applied for 60 s in the etched surface of the veneer. After drying with air spray, the adhesive Excite F (Ivoclar Vivadent) was gently applied, dried with air spray and photocured for 20s.

For group I (n=10), the WO base paste was applied in the veneers, taken to the teeth surface and pressed with a special appliance developed to standardize the cementation pressure of 1 kg throughout the whole study. For group II (n=10) the same procedures were followed for the Y base paste. Each specimen was photocured for 60 s: 20s on the buccal face and 20s on each proximal face.

The specimens were next subjected to AAA (Accelerated Aging System for Non-Metal materials, UV-B/Condensation; Adexim-Comexim Industry, Sao Paulo, Brazil). The specimens were placed in aluminum plates and exposed to 8 UV-B light sources with a radiation of 280/320 nm, at a distance of 50 nm, in a condensation chamber. The program was set for 4 hours of UV-B exposure at 50°C, and 4 hours of condensation at 50°C, for a maximum of 400 hours.

Color measurements were made using an ‘Easy Shade’ Vita probe spectrophotometer (Vita Easy Shade, Vita, Germany). Spectrophotometers measure CIE-L*a*b* values giving a numerical representation of a 3D measure of color. The L* describes the lightness of the object being assessed, a* value defines the color on the red-green axis and b* on the yellow-blue axis[20]. The specimens were submitted to color readings in three moments: after the preparation (only the substrate), after the cementation and polymerization of the veneers and after the AAA. The readings were made against a standard white background (Standard for 45º, 0º Reflectance and Color Garder Laboratory Inc. Maryland, EUA).

To determine the total color change (ΔE*), the formula below was used:

$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$; where ΔL* is the variation of L*, Δa* is the variation of a*, and Δb* is the variation of b*.

Three different ΔE* were obtained in this study. The first one represented the comparison of the values measured in the substrate and the ones obtained immediately after the cementation of the PLV (called ΔE^*_1). The second one comparing the coordinates obtained immediately after cementation and the ones measured after AAA (ΔE^*_2). And the last one comparing substrate measurements and the ones obtained after the specimens suffered AAA (ΔE^*_3) (Fig. 1).

Values obtained for L*, a*, b* and ΔE* were subjected to statistical analysis in SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, EUA) with a significance level of 0.05 ($p<0.05$). For paired comparisons of independent samples, the T-Test was applied for parametric samples and Mann-Whitney test was used for the non-parametric ones. In the comparisons of multiple variables, ANOVA and Tukey were used for the parametric samples, and for non-parametric ones, Dunn Method and Kruskal-Wallis test were applied.

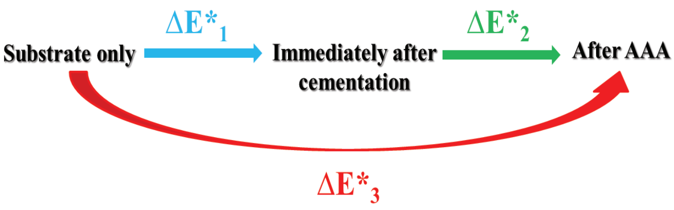

Figure 1. Representation of the different ΔE* obtained in the study.

RESULTS

The means, standard deviations and sums of ranks for L*, a*, b* and ΔE* are shown in Tables 1 and 2.

Table 1. Means and standard deviations (±S.D.) of ΔE* for each cement shade.

Groups	ΔE^*_1	ΔE^*_2	ΔE^*_3
White-Opaque	33.61 (7.12)^{a,A}	2.02 (0.99)^{b,A}	37.00a (7.24)^{a,A}
Yellow	28.30 (6.43)^{a,A}	3.34 (0.53)^{b,B}	28.87(6.25)^{a,A}

Means followed by the same superscript minute letter (a or b) denote no statistical difference among the different ΔE* (ΔE^*_1, ΔE^*_2, ΔE^*_3) within the same cement shade ($p > 0.05$).
Means followed by the same capital letter (A or B) denote no statistical difference between the cement shades (White-Opaque and Yellow) within each ΔE* ($p > 0.05$).

Table 2. Means and standard deviations (±S.D.) of L*, a* and b* values for each measurement. The sums of ranks, for samples with non-parametric distribution, are shown in parentheses.

	Before cementation (substrate)		Immediately after cementation		After AAA	
	White Opaque	Yellow	White Opaque	Yellow	White Opaque	Yellow
L*	73.13 ± 6.22^{a,A}	74.59 ± 11.73^{a,A}	100.00 ± 0.00^{a,B} (110.00)	99.85 ± 0.47^{a,B} (100.00)	96.03 ± 1.41^{a,B}	93.60 ± 1.45^{b,A}
a*	9.05 ± 2.34^{a,A}	7.67 ± 3.45^{a,A}	1.29 ± 0.55^{a,B}	1.35 ± 0.39^{a,B}	-1.05 ± 0.36^{a,C}	-0.73 ± 0.43^{a,B}
b*	48.42 ± 7.76^{a,A}	47.56 ± 6.00^{a,A}	15.40 ± 3.01^{a,B}	19.90 ± 2.64^{b,B}	11.77 ± 2.24^{a,B}	19.02 ± 2.65^{b,B}

Values in the same line with same superscript minute letter (a or b) denote no statistical difference between cement shades in the same measurement period (before cementation, immediately after cementation or after AAA) ($p > 0.05$).
Values in the same line with same superscript capital letter (A, B or C) denote no statistical difference among measurement times within the same cement shade (White-Opaque and Yellow) ($p > 0.05$).

The results for ΔE* are shown in Table 1. There were significant differences between the cements when comparing the ΔE^*_2, as the Y cement presented more color change (higher ΔE*) than the WO one ($p<0.05$). There were no statistically significant differences between other ΔE* (ΔE^*_1 and ΔE^*_3) obtained ($p>0.05$).

When comparing the color changes (ΔE*) within the same cement, the ΔE^*_2 values were statistically different from the other ones obtained for both cements ($p<0.05$). For WO and Y, ΔE^*_3 presented the highest ΔE*.

The results for L*, a* and b* are shown in Table 2. There were no significant differences in L*, a* and b* measured in the substrate (before cementation) between the cements ($p>0.05$). Immediately after cementation, there were significant differences between the cements for b* values, where Y showed higher b* than WO ($p<0.05$). For L* and a* in the same moment, there were no significant differences between cements ($p>0.05$). After AAA, there were no significant differences only in the a* coordinate between the cements ($p>0.05$). The L* and b* at this moment were significantly different between cements, where L* was higher in WO and b* was higher in Y ($p<0.05$).

When comparing the values of L* and b* within WO cement, there were significant differences between the measurements obtained before cementation (only substrate) and immediately after cementation; and between the substrate and the values found after AAA ($p<0.05$). The specimens presented the highest L* immediately after cementation and the lowest before it, while the highest b* was registered before cementing the PLVs and the lowest after AAA. After AAA and before it (immediately after cementation) L* and b* presented no statistical differences ($p<0.05$). All comparisons of a* within WO cement presented significant differences ($p>0.05$). The lowest value of a* was registered after AAA and the highest in the substrate, before cementation.

For comparisons within Y cement, L* values showed significant differences when comparing this coordinate before and after cementation; and comparing the L* after AAA and before it (immediately after cementation) ($p<0.05$). There were no significant differences between L* values obtained before cementation (substrate) and after AAA ($p>0.05$). The lowest L* value was found before cementation (substrate) and the highest after cementation. The values of a* and b* showed no significant differences before (immediately after cementation) and after AAA ($p>0.05$). There were significant differences between a* and b* measured before cementation and after it; and comparing before cementation and after AAA ($p<0.05$), being the a* and b* before cementation the highest.

DISCUSSION

The purpose of the different shades of resin cements is to achieve clinically acceptable restorations with good color matching to the adjacent dentition[11]. In the production of the PLV, the porcelain shade is matched to the shade of the adjacent teeth. However, the final color of translucent ceramic restorations is determined by the thickness of the porcelain, the thickness and color of the luting agent and the color of the underlying tooth structure[6,11,23,24]. In this study, bovine teeth were used as substrate so it could mimic the clinical situation as much as possible. The teeth had minimum preparation without exposing dentin, because the porcelain veneers are etched mostly to enamel. The measurements of L*, a* and b* in the substrate, before cementation, were statistically similar in all groups, showing a standardization of the background used in this study.

In this study, the luting agents composed a layer of approximately 0.1 mm thick bonded to a 0.6 mm ceramic disc and a thin enamel substrate in order to reproduce clinical condition. During cementation, the translucency of PLVs is important because of the need to cure the underlying resin cements effectively[5,14]. The ceramic used in the current study has translucent characteristics and a very low thickness in order to provide higher degree of conversion and indicate any significant color changes in the luting material. The results of this study showed that the PLVs were able to mask the background despite the resin cement color[23,25], as most of the coordinates showed no differences between cements, except from the b* coordinate. This coordinate was higher in the specimens cemented with the Y cement, as expected, since a higher b* indicates a more yellowish shade. This shade might be due to pigments added by the manufacturer to achieve the desired color (manufacturer's information). The absence of difference in L* coordinate between cements after cementation may indicate that the lightness is determined mostly by the PLV and not by the resin cement[20].

According to the manufacturert of the AAA device, 300 hour of weathering is equivalent to 1 year of service, and that the color change was induced in the first 100 or 300 h of the process[21]. According to the literature, color alteration occur in the first 300 hours of the aging process, as the composites water sorption stops with the saturation and stabilization of the polymeric chains[1,26-28]. In this study, the AAA was conducted for 300 h, considering the manufacturer recommendations and the literature reports to achieve the total color change expected.

The optical behavior of esthetic materials can be measured by visual or photographic techniques, even though they are highly subjective[6,29]. Electronic devices have been developed to eliminate the subjectivity of the human eye, such as colorimeters and spectrophotometers[5,6,24]. In these systems, the location of a particular shade in the color space is defined by three coordinates: L*, a* and b*[4,20]. The widely recognized CIE L*a*b* color order system, developed in 1978 by the Comission Internatinale de l'Eclairage (International Comission of Illumination), is commonly used in dental research[4,6,10,11,16,17,20-23,26,30-34].

After the AAA process, the Y cement presented even lower lightness and even more yellowish shade, with an increase in b* and a decrease in L* measurements compared to WO. Lowering of L* is a consistent data with the literature[5,15] and suggest that resin-based materials tend to darken after AAA. According to some authors, the yellowing of a material over time could be related to the exposition of Bis-GMA-based material to ultraviolet light and heat[5,33]. As composite materials age, the water sorption characteristics of the resin monomers may contribute to differences in the degree of color stability[15]. Considering this characteristic, the manufacturer of the luting cements studied, Ivoclar Vivadent, developed the Variolink Veneer especially for cementation of thin PLVs, which have no Bis-GMA on its matrix, only UDMA[5] (Manufacturer information). Compared with Bis-GMA, UDMA appears to be less susceptible to staining[15]. Contemplating the decision of the manufacturer considering the PLVs, it can be inferred that possibly the amount of Bis-GMA is smaller in the WO base when compared to the Y one, as a less yellow color is desired for the first one. Photo-initiators degradation can be related to yellowing after AAA as well[5,15,16,33]. However, no information on different initiators for the two different shades of cements was provided by the manufacturer.

Espectrophotometers define the location of a particular shade in the color space by three coordinates: L*, a* and b*[4,20]. The total color change of a material can be accessed using these coordinates to calculate the ΔE*[11]. Usually, ΔE* values lower than 1.0 were considered undetectable by the human eye, values between 1.0 and 3.3 were considered visible by trained operators, but clinically acceptable, and ΔE* values greater than 3.3 were considered visible to non-trained people and clinically unacceptable[5,10,14,21,25,32,33,35].

CONCLUSION

According to the methodology used in this study, the total color changes suffered by the two cements were detectable to the human eye (ΔE* > 1.0). The WO cement had a more steady behavior, with a ΔE* of 2.02, while the Y cement showed a ΔE* of 3.34, slightly beyond the threshold used in this study. With AAA, only the Y shade showed a ΔE* clinically unacceptable, becoming more yellow (higher b*) and losing lightness (lower L*).

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RESUMO

Objetivos: O objetivo do presente estudo foi avaliar a influência da cor do cimento resinoso na tonalidade final de facetas de porcelana minimamente invasivas, após envelhecimento artificial acelerado (EAA). Material e Métodos: 20 dentes bovinos foram coletados, preparados e divididos em dois grupos. As raízes foram removidas e a face vestibular foi polida para obter uma superfície plana. Discos de porcelana (IPS Empress Esthetic) foram confeccionados na cor ET1 e espessura de 0,6 mm. Os dentes e as superfícies dos discos foram preparados de acordo com as recomendações do fabricante. Para o grupo I (n=10) foi usado o cimento resinoso White-Opaque (WO) pasta-base, e para o grupo II (n-10) utilizou-se o Yellow (Y) pasta-base. Cada espécime foi fotopolimerizado por 60 s. Os espécimes foram então submetidos ao EAA. Eles foram submetidos a leituras de cor com auxílio de um espectrofotômetro em três momentos: após o preparo (apenas o substrato), após a cimentação e polimerização das facetas e após o EAA. Foram obtidos valores de L*, a* e b* e o total da variação de cor foi calculado (ΔE*). Os valores obtidos foram submetidos à análise estatística no SPSS 17.0 para Windows, com nível de significância de 0,05. Resultados: O cimento Y apresentou maior ΔE*, menor L* e maior b* após o EAA em comparação com o WO. Conclusão: Ambos os cimentos têm capacidade de mascarar a cor do substrato. Com o EAA, apenas o Y apresentou um valor de ΔE* inaceitável clinicamente, se tornando mais amarelo (maior b*) e perdendo luminosidade (menor L*).

PALAVRAS-CHAVE: Facetas dentárias, cimentos de resina, envelhecimento, testes de percepção de cores.

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