PRÓ-REITORIA ACADÊMICA
DIRETORIA DE PESQUISA, EXTENSÃO E PÓS-GRADUAÇÃO
PROGRAMA DE MESTRADO PROFISSIONAL EM ODONTOLOGIA

LUIZ ANDRÉ PORDEUS BATISTA

ANÁLISE OBJETIVA DA COR EM TRATAMENTO COM LAMINADOS CERÂMICOS: ESTUDO IN VIVO

Maringá
2020

PRÓ-REITORIA ACADÊMICA
DIRETORIA DE PESQUISA, EXTENSÃO E PÓS-GRADUAÇÃO
PROGRAMA DE MESTRADO PROFISSIONAL EM ODONTOLOGIA

LUIZ ANDRÉ PORDEUS BATISTA

ANÁLISE OBJETIVA DA COR EM TRATAMENTO COM LAMINADOS CERÂMICOS: ESTUDO IN VIVO

Dissertação em formato artigo apresentada ao Programa de Mestrado Profissional em Odontologia, do Centro Universitário Ingá UNINGÁ, como parte dos requisitos para obtenção do título de Mestre em Odontologia, área de concentração Prótese Dentária.

Orientadora: Profa. Dra. Nubia Inocencya Pavesi Pini

Maringá
2020

LUIZ ANDRÉ PORDEUS BATISTA

ANÁLISE OBJETIVA DA COR EM TRATAMENTO COM LAMINADOS CERÂMICOS: ESTUDO IN VIVO

Dissertação em formato artigo apresentada ao Programa de Mestrado Profissional em Odontologia, do Centro Universitário Ingá UNINGÁ, como parte dos requisitos para obtenção do título de Mestre em Odontologia, área de concentração Prótese Dentária.

Maringá, ___ de _____ de 2020.

BANCA EXAMINADORA

_____
Profa. Dra. Nubia Inocencya Pavesi Pini
UNINGÁ

_____
Prof. Dr. Waldemir Francisco Viera Jr
São Leopoldo Mandic

_____
Profa. Dra. Aline Akemi Mori
UNINGÁ

DEDICATÓRIA

Dedico este trabalho ...

A Deus por me permitir alcançar cada objetivo até aqui.

Aos meus pais, **José & Eliane**, a quem devo minha vida.

Aos meus irmãos **Luiz Paulo & Heitor**, que sempre estiveram ao meu lado me apoiando e incentivando a cada nova jornada.

Aos meus amigos e demais familiares que sempre me apoiam a conquistar meus objetivos.

E em especial ao meu filho **Davi**, por ser a principal fonte de energia que me abastece a cada dia pqra que eu possa percorrer o caminho da vida.

AGRADECIMENTOS

À Profa. Dra. **Nubia Pini**, minha orientadora, por acreditar em mim, confiar no meu trablho e por ter tido papel fundamental para que eu conseguisse chegar até aqui.

Ao Prof. Dr. **Daniel Sundfeld**, por sua dedicacção, empenho para que nós alunos tivéssemos um curso de excelência e por sua amizade.

Ao Profa. Dra. **Aline Mori**, por todo conhecimento compartilhado, sua amizade, carinho e respeito

Ao Profa. Dra. **Fernanda Ferruzzi**, por sua amizade e carinho, e por compartilhar seus conhecimentos

Aos amigos de turma **Marcos, Pablo, Márcia, João Fagan e João Jr**, por terem sido os melhores companheiros de turma que alguém pode ter. Obrigado pelo carinho, respeito e companheirismo, levarei para sempre vocês no meu coração.

Aos funcionários da UNINGÁ pela ajuda e em especial à **Juliana** que contribuíram de maneira positiva na realização dessa pesquisa.

Ao Centro Universitário Ingá UNINGÁ e ao Programa de Mestrado Profissional em Odontologia, a todos os professores, pela oportunidade de aprendizado.

RESUMO

Objetivo: Este estudo teve como objetivo avaliar, in vivo, a propriedades da cor em cada etapa realizada no tratamento com facetas de cerâmica e correlacioná-la com a espessura do laminado e tipo de dente tratado. **Material e Métodos:** Dez pacientes submetidos a tratamento estético com laminados ceramicos em dentes antero superiores foram incluídos como participantes. A análise de cor com o espectrofotômetro foi realizada no início do estudo, após a preparação do dente, imediatamente após a cimentação (final 1) e após 12 meses de acompanhamento. Os dados de ΔL*, Δa*, Δb*, ΔE, ΔE00 e ΔSGU foram obtidos. A espessura do laminado cerâmico também foi medida com a utilização de especimetro analógico. Cada paciente foi considerado como um bloco estatístico e os resultados médios de cada dente (incisivos centrais, incisivos laterais e caninos superiores) foram apresentados. Utilizou-se ANOVA e teste de Tukey para comparar os resultados para cada dente; Teste de Pearson para correlacionar espessura e mudança de cor (ambas as análises considerando ΔL*, Δa*, Δb*, ΔE e ΔE00); e teste de Friedman e Kruskal-Wallis para avaliar os resultados do ΔSGU (α = 5%). **Resultados:** Não houve diferenças na espessura da cerâmica considerando os dentes tratados. Em relação a ΔL*, Δa*, Δb*, o tratamento com laminados produziu alterações apenas em Δb *, considerando as medidas finais em relação à linha de base ($p<0,05$). Considerando ΔE, apenas os caninos apresentaram alterações perceptíveis ($p<0,05$). Em relação a ΔE00, não foram encontradas diferenças ($p>0,05$). Houve correlação significativa ($p<0,05$) entre espessura da cerâmica e ΔL* ($r=-0,372$), Δa* ($r=0,49$) e Δb* ($r=0,37$). A variação de ΔSGU foi significativa ao se comparar as análises pós-cimentado com após o preparo ($p<0,05$). **Conclusão:** O tratamento com laminados de cerâmicos resultou em mudança de cor principalmente em função do eixo b*, produzindo diferenças objetivas em relação à análise ΔE, principalmente no caso de caninos. Existe uma correlação em relação à espessura da cerâmica e mudança de cor após o preparo.

Palavras-Chave: Cor, laminados cerâmicos, avaliação da tonalidade.

ABSTRACT

Objective analysis of color in treatment with ceramic laminates: in vivo study

Objective: This study aimed to assess, in vivo, the color proprieties in each stage performed in the treatment with ceramic laminate and to correlate it with the thickness of the laminate and to the tooth treated. **Material and methods:** Ten patients who underwent to esthetic treatment were included as participants. Color analysis with VITA Spectrophotometer were performed at baseline, after tooth preparation, immediately after cementation (final 1) and after 12 months of follow-up (final 2). Data of ΔL*, Δa*, Δb*, ΔE, ΔE00 and ΔSGU were obtained. Thickness of the veneer was also recorded. Each patient was considered as a statistical block and the mean results for each tooth (upper central incisors, lateral incisors and canines) were presented. ANOVA and Tukey's test were used to compare the results for each tooth; Pearson's test to correlate thicnkess and color change (both analysis considering ΔL*, Δa*, Δb*, ΔE and ΔE00); and Friedman and Kruskal-Wallis test to evaluate the ΔSGU results (α = 5%). **Results:** There were no differences in the ceramic thickness considering the teeth treated. In relation to ΔL*, Δa*, Δb*, the treatment with laminates produced changes only in Δb*, considering the final measurements in relation to baseline ($p<0.05$). Considering ΔE, just the canines showed perceptible changes ($p<0.05$). In relation to ΔE00, no differences were found ($p>0.05$). There was significant correlation ($p<0.05$) between ceramic thickness and ΔL* ($r=-0.372$), Δa* ($r=0.49$) and Δb* ($r=0.37$). The ΔSGU variation were significant when compared the final measurements with the preparation. **Conclusions:** The treatment with ceramic laminate resulted in color change mainly depending on the b* axis, producing objective differences, concerning ΔE analysis, mainly in case of canines. There is a correlation in relation to ceramic thickness and color change after preparation.

Keywords: Color, Ceramic veneers, shade evaluation.

SUMMARY

1 - Introduction

1 INTRODUCTION

Aesthetics can be defined as the science of human sensory faculties that deals with capturing beauty and is a concept that is based on philosophy, history, the arts and common sense, the psychosocial response of satisfaction with the appearance of anterior teeth when a patient smiles may be influenced by the color. (Yilmaz, Gonuldas et al. 2014, Brielmann and Pelli 2018). Aesthetics is based on subjective criteria, since it is a sensation or judgment that obeys individual preferences, guided by cultural, geographical and temporal. Tooth color is considered of great value to the esthetic and appearance of the smile (Paravina, Ghinea et al. 2015) and, frequently, this is the main expected outcome for patients who undergo an esthetic treatment with ceramic laminate(Hallmann, Ulmer et al. 2019). Color is the property of a substance to reflect or absorb some of the visible white light and perceptual ability of the human eye (Witzel and Gegenfurtner 2018). Clinical studies evaluation how the ceramic veneers change the final tooth color of the smile are lacking.

Besides to improve tooth color, laminate veneers are indicated to increase tooth size, close diastemas, and to correct form and discoloration. (Calamia and Calamia 2007, de Azevedo Cubas, Camacho et al. 2011, Shono and Al Nahedh 2012) Clinically, the treatment with ceramic laminate presents several advantages, mainly in relation to optical properties and mechanical resistance, which make them a treatment with higher durability and longevity (Kelly, Nishimura et al. 1996). In relation to the color, ceramic laminate are considered more stable than the composite resin ones, once the composite material has a lower degree of aesthetics due to the lack of translucency of the material and color stability in time. Clinical trials relate emergence of porous surface and marginal discoloration in composite veneers overtime. (Meijering, Creugers et al. 1998, Gresnigt, Kalk et al. 2012) Nowadays, ceramic laminate may be performed in a conservative way, once newer generations of all-ceramic systems and adhesive cements allow dentists to use a minimally invasive approach and make thinner restorations, saving tooth structure and providing superior esthetic results (Czigola, Abram et al. 2019).

The final color of the ceramic laminate depends on the interaction between three main colors: ceramic material, dental substrate and the selected cementing agent; which associated with the thickness of the veneer and its translucency, will establish the chromatic result of the restoration.(Shono and Al Nahedh 2012) Studies point to translucency as one of the main factors in aesthetic aesthetics and a critical consideration in material selection. (Kelly, Nishimura et al. 1996, Vichi, Louca et al. 2011, Bagis and Turgut. 2013) Heat pressed ceramics, as lithium dissilicate, have a great variety of colors and translucency levels.(Soim, Strimbu et al. 2018) The color of ceramic restorations varies according to many factors such as the thickness of porcelain (O'Brien, Kay et al. 1991) and of dentin; (Jacobs, Goodacre et al. 1987, Shokry, Shen et al. 2006) trademark (Hammad and Stein 1990, Ozturk, Uludag et al. 2008) and condensation techniques, (O'Brien, Kay et al. 1991) surface smoothness, (Brewer, Garlapo et al. 1990) degree of firings (Hammad and Stein 1991), and number of firings (Jorgenson and Goodkind 1979, Barghi and Lorenzana 1982).

To understand how the optical change of the tooth with a ceramic laminate occurs, the purpose of this longitudinal in vivo evaluation was to assess the color alteration between each stage of the treatment with laminates (initial, after tooth preparation, and after cementation), correlating the obtained data with the ceramic thickness. The hypotheses were that the kind of tooth prepared (central incisors, lateral incisors and canines) and the thickness of the ceramic would not influence on the color change of the teeth treated with ceramic laminate.

2 - Objective

2 OBJECTIVE

This study aimed to assess, in vivo, the color alteration in each stage performed in the treatment with ceramic laminate and to correlate it with the thickness of the laminate.

3 - Material e Methods

3 MATERIAL AND METHODS

3.1 Experimental Design

This 12-month longitudinal clinical evaluation was approved by the local Ethical Committee (CAAE 20311519.8.0000.5220). Written informed consent was obtained from the 10 participants included in the study. All participants were patients who undergo do the clinic seeking for esthetic treatment. Following the conditions and indications to the esthetic treatment with ceramic veneers, they were invited to participate to the study. The primary outcome was to evaluate color alteration in function of veneer thickness and kind of tooth treated. Therefore, blindness was not possible as well as the standardization of the products / materials used. The general conditions, as presence of active caries and periodontal disease, were prioritized for the indication of this kind of treatment as usually should be. Patients with severe-color alteration were excluded. No pregnant or breast-feeding woman, or smokers, took part of the study. The study included participants of either gender (70% men), aged 25 to 54 years, and with any tooth shade. Color analysis was performed using a spectrophotometer (VITA Easyshade, VITA Zanhnfabrik, Bad Säckingrn, Germany) to assess ΔL*, Δa*, Δb*, ΔE from ΔE00 from L*, a* and b* values; and ΔSGU, from scored following the VITA color shade. Each participant was considered as a statistical block, being evaluated the mean or median values obtained for each tooth (central incisor, lateral incisor or canine), in each analysis.

3.2. Treatment

All stages of treatment were performed by the same operator and, in this stance, the conditions of work was always the same (planning with impression for wax-up and mock-up, preparation with new diamond burs, impression with polyvinyl siloxane material, provisionalization with bysacrylic resin Protemp - 3M ESPE, cementation under isolation. The sequence of treatment was follow: 1) Initial clinical evaluation with obtaining of photographs and dental casts for planning; 2) Mock-up appointment for approval of the final outcome of the treatment; 3) Tooth preparation, impression and provisional restorations; 4) Cementation and 5) Appointments for follow-up. All ceramic laminate were made by pressable lithium dissilicate HTBL4 (30%); HTBL3

(30%); HTBL2 (10%); HTA1 (10%); MOBL4 (20%) (E-Max, Ivoclar Vivadent AG, Schaan / Liechtenstein), obtained from the same technician. The color of ceramic and cements were not standardized and it was chosen in according to the patient. A summary of the main materials used is in Table 1.

Table 1. Materials used in the treatments.

Procedure	Material	Specifications and use in participants (%)
Initial Impression	Polivyinyl siloxane	Virtual - Ivoclar Vivadent (100%)
Tooth Preparation	Diamond burs	1014, 2135, 2135F - KG Sorensen (100%)
	Abrasive disks	Pop-On - 3M ESPE (100%)
Impression after preparation	Retraction cords Polivyinyl siloxane	Ultrapack 000 - Ultradent (100%) Virtual - Ivoclar (100%)
Provisional restorations	Bysacrylic Resin	Protemp - 3M ESPE (100%)
Ceramic	Lithium dissilicate	E-MAX Press - Ivoclar Vivadent *HTBL4 (30%); HTBL3 (30%); HTBL2 (10%); HTA1 (10%); MOBL4 (20%)
Cementation	Fluoridric Acid Silane Phosphoric acid Adhesive Conventional resin photoactivated cement	Porcelain Etch - FGM Monobond N - Ivoclar Vivadent Ultra-etch - Ultradent (100%) Single Bond II - 3M ESPE Variolink Veneer Light - Ivoclar Vivadent (70%) Variolink Veneer Neutral - Ivoclar Vivadent (10%) NX3 Opaque White - Kerr (10%) AllCem E-bleach - FGM (10%)

No previous bleaching procedure and the tooth preparation was performed in according with the previously determined by the mock-up. The thickness of the

preparation was always controlled by the silicone matrix guide obtained from the wax-up. All the preparations were positioned 0.5 mm under the gingival margin following the anatomy of the teeth. The proximal and occlusal regions were involved when necessary. After placement of the retraction cords in the prepared tooth, maxillary arch impressions were made with polyvinyl siloxane (Virtual - Ivoclar Vivadent) with the double-mix technique and Type IV gypsun (GC Fujirock EP, GC America) were obtained to be scanned and follow the production of the pressable ceramic veneers. The provisionalization was performed with bysacrilyc resin (Protemp - 3M ESPE).

Before the cementation, each veneer was analyzed in relation to the presence of stains or cracks and the thickness of each one was noted. The cementation was performed as regularly recommended, (Peumans, Van Meerbeek et al. 2000, Duran Ojeda, Henriquez Gutierrez et al. 2017) under rubber dam isolation using the conventional light-activated resin cements (Variolink Veneer Light - Ivoclar Vivadent (70%) Variolink Veneer Neutral - Ivoclar Vivadent (10%) NX3 Opaque White - Kerr (10%) AllCem E-bleach - FGM (10%). The light polimerization was performed using a polywave led (Valo - Ultradent).

3.3 *Color analysis*

Color analysis were performed at initial (baseline), at the preparation appointment (preparation), immediately after cementation (final 1) and at 12 months (mean of 7 months) follow-up (final 2), using a clinical spectrophotometer (VITA Easyshade, VITA Zanhnfabrik, Bad Säckingrn, Germany). For each patient, a individualized guide made with polivynyl siloxane material (Virtual, Ivoclar Vivadent AG, Schaan, Liechtenstein) was obtained from the wax-up. In this guide, in each tooth - central and lateral incisors and canine - a 6-mm diameter window were positioned on middle of the buccal surface to standardize the position for the color evaluation. The color measurements were recorded in the CIE L*a*b* system, which defines color on 3 coordinates: L* lightness, raging from 0 (black) to 100 (white); and a* and b*, chromatic characteristics rafrom red (+a*) to green (-a*) and yellow (+b*) to blue (-b*) (Șoim et al., 2018; Marchionatti et al., 2017). The color was measured 4 times, and the mean of L*, a*, and b* values were calculated. The variation of each coordinate between the first and subsequent measurements was calculated as follows: ([$\Delta L^* = L^*_{prep/final1/fina2} - L^*_{initial}$]; [$\Delta a^* = a^*_{prep/final1/final2} - a^*_{initial}$], and [$\Delta b^* = b^*_{prep/final1/final2} - b^*_{initial}$].

The CIELab color change (ΔE) was calculated according to the following formula: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{½}$.

Color differences were also calculated using the CIEDE2000 formula as follows: $\Delta E00 = [(\Delta L'/K_L S_L)^2 + (\Delta C'/K_c S_c)^2 + (\Delta J'/K_H S_H)^2 + R_T(\Delta C'/K_C S_C)\ (\Delta H'/K_H S_H)]^{½}$, where ΔL', ΔC', and ΔH' are the differences in lightness, chroma, and hue, respectively, between the baseline and the subsequent color readings; R_T is the rotation function corresponding to chroma and hue difference interaction in the blue region; S_L, S_C and S_H are weighting terms for adjustment of the total color difference for variation in perceived magnitude with variation in the location of the color coordinate difference between 2 color measurements; and K_L, K_C and $K_{H\ o}$ are correction terms for the experimental conditions.(Ghinea, Perez et al. 2010)

The Vita EasyShade also provide the qualitative analysis in according to the VITA Classical or VITA 3-D Master shade guide. The results for the VITA Classical guide were scored from 1 (B1) to 16 (C4) in decreasing order of value: B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, and C4. The smaller the numeric value, the lighter the tooth. From this, the ΔSGU (variation in shade unit guide) was calculated from each measurement (preparation, final 1 or final 2) in relation do baseline (ΔSGU = Prep/final1/final2 - baseline). This was performed for each tooth individually.

3.4 *Statistical Analysis*

The data related to the color analysis, ΔL^*, Δa^*, Δb^*, ΔE and ΔE_{00}, and the thickness of the laminate veneers were verified with the Shapiro-Wilk test to check normal distribution and possible outliers. After that, the ANOVA and Tukey tests were applied to compare the results obtained for each kind of tooth (central incisors, lateral incisors and canines). Pearson's correlation was used to evaluate the relation between ceramic veneers thickness and the color variables.

The data related to the ΔSGU were evaluated with non-parametric tests. Friedman test were used to evaluate the color variation in different moments, for each tooth. The comparisons between color measurements and different tooth was

done with Kruskal-Wallis and Dunn tests. The level of significance for all analysis was set at 5%.

4 - Results

4 RESULTS

Table 2 presents the thickness of ceramic laminates in according to each kind or tooth treated. The results showed a similar variation in thickness without statistical difference when compared the central incisors, lateral incisors and canines.

Table 2. Thickness of ceramic veneers in according to the teeth prepared.

	Final laminate thickness (mm)					
Teeth	Mean	Standard Deviation	Median	Min	Max	
Central incisors (CI)	0.9	0.2	1.0	0.5	1.1	a
Lateral incisors (LI)	1.0	0.1	1.0	0.8	1.1	a
Canines (C)	0.9	0.2	0.8	0.7	1.25	a
All teeth (CI, LI, C)	0.9	0.2	0.9	0.5	1.25	

*Different letters indicate statistical differences between the measurements analyzed.

Table 3 shows the results for ΔL*, Δa* and Δb* comparing the different measurement for each tooth, as well as the result for all teeth. In general, tooth preparation result in an increase of the color axes (a* and b*), which reduce in the analisys that compare the final measurements with baseline. In any situation, central incisors, lateral incisors, canines or considering all teeth, there was significant difference just for Δb* for the variation considering the final measurements (Final and Final 2) in relation to baseline ($p<0.05$). Analyzing the results, it can be seen that, in this situations, there was a reducing in Δb* values.

Table 3. Mean (+/- SD) of CIE L*a*b* values comparing the different measurements.

		ΔL*	Δa*	Δb*
	Baseline vs.			
Central incisors (CI)	Tooth preparation	3.4 (4.8) a	0.3 (2.0) a	6.5 (5.5) a
	Final – After cementation (immediate)	1.4 (4.3) a	-0.9 (1.4) a	-5.0 (5.2) b
	Final 2 – After cementation (1 year)	0.3 (4.0) a	-1.0 (1.4) a	-5.6 (4.8) b
	Baseline vs.			
Lateral incisors (LI)	Tooth preparation	1.5 (3.1) a	-0.2 (1.0) a	8.3 (6.0) a
	Final – After cementation (immediate)	-0.8 (4.0) a	-0.6 (1.5) a	-5.6 (5.4) b
	Final 2 – After cementation (1 year)	-1.7 (4.1) a	-0.4 (1.5) a	-5.1 (3.7) b
	Baseline vs.			
Canines (C)	Tooth preparation	-4.6 (7.5) a	0.2 (0.8) a	5.1 (5.2) a
	Final – After cementation (immediate)	-0.8 (3.4) a	0.3 (1.3) a	-4.1 (3.2) b
	Final 2 – After cementation (1 year)	-2.8 (2.0) a	0.4 (1.4) a	-6.2 (5.5) b
	Baseline vs.			
All teeth (CI, LI, C)	Tooth preparation	-0.50 (6.7) a	0.13 (1.4) a	6.62 (5.6) a

	Final – After cementation (immediate)	-0.07 (4.0) a	-0.41 (1.4) a	-5.41 (5.3) b
	Final 2 – After cementation (1 year)	-1.11 (3.9) a	-0.34 (1.5) a	-5.61 (4.6)b

*Different letters indicate statistical differences between the measurements analyzed.

Considering ΔE e ΔE_{00} analysis, Table 4 shows statistically significant differences just for ΔE in case of canine, once the evaluations considering the final measurements and baseline were statistically different from baseline x tooth preparation ($p<0.05$).

Table 4. Mean +/- SD of ΔE e ΔE_{00} values comparing the different measurements.

		ΔE	ΔE_{00}
	Baseline vs.		
Central incisors (CI)	Tooth preparation	9.4 (5.8) a	6.0 (3.6) a
	Final – After cementation (immediate)	7.5 (4.0) a	5.2 (2.2) a
	Final 2 – After cementation (1 year)	7.4 (3.8) a	5.0 (2.0) a
	Baseline vs.		
Lateral incisors (LI)	Tooth preparation	9.1 (5.8) a	5.1 (3.3) a
	Final – After cementation (immediate)	7.6 (4.5) a	5.2 (2.7) a
	Final 2 – After cementation (1 year)	6.9 (2.9) a	5.7 (2.8) a
	Baseline vs.		
Canines (C)	Tooth preparation	10.1 (5.1) a	6.6 (3.6) a
	Final – After cementation (immediate)	5.7 (2.6) b	4.8 (3.2) a
	Final 2 – After cementation (1 year)	6.4 (2.0) b	5.9 (3.4) a
	Baseline vs.		
All teeth (CI, LI,	Tooth preparation	9.54 (5.4) a	6.0 (3.4) a

C)	Final – After cementation (immediate)	6.96 (3.8) a	5.1 (2.6) a
	Final 2 – After cementation (1 year)	7.95 (4.8) a	5.8 (3.0) a

*Different letters indicate statistical differences between the measurements analyzed.

The Pearson's correlation was statistically significant just for ΔL*, Δa* and Δb* obtained from the measurements after tooth preparation and baseline, in relation to ceramic thickness. According with Figure 3, it can be seen that ΔL* decrease in while the thickness of ceramic increase (r=-0.372 ; p=0.04). For Δa* and Δb* a positive correlation is verified, the values increase as the thickness increase (Δa*: r=0.49 ; p=0.05 / Δb*: r=0.37 ; p=0.04). In relation to the other analysis - ΔE e $\Delta E_{00,}$ and the other measurements (final conditions in relation to baseline), no significant correlations were found (p.0.05) (data no shown).

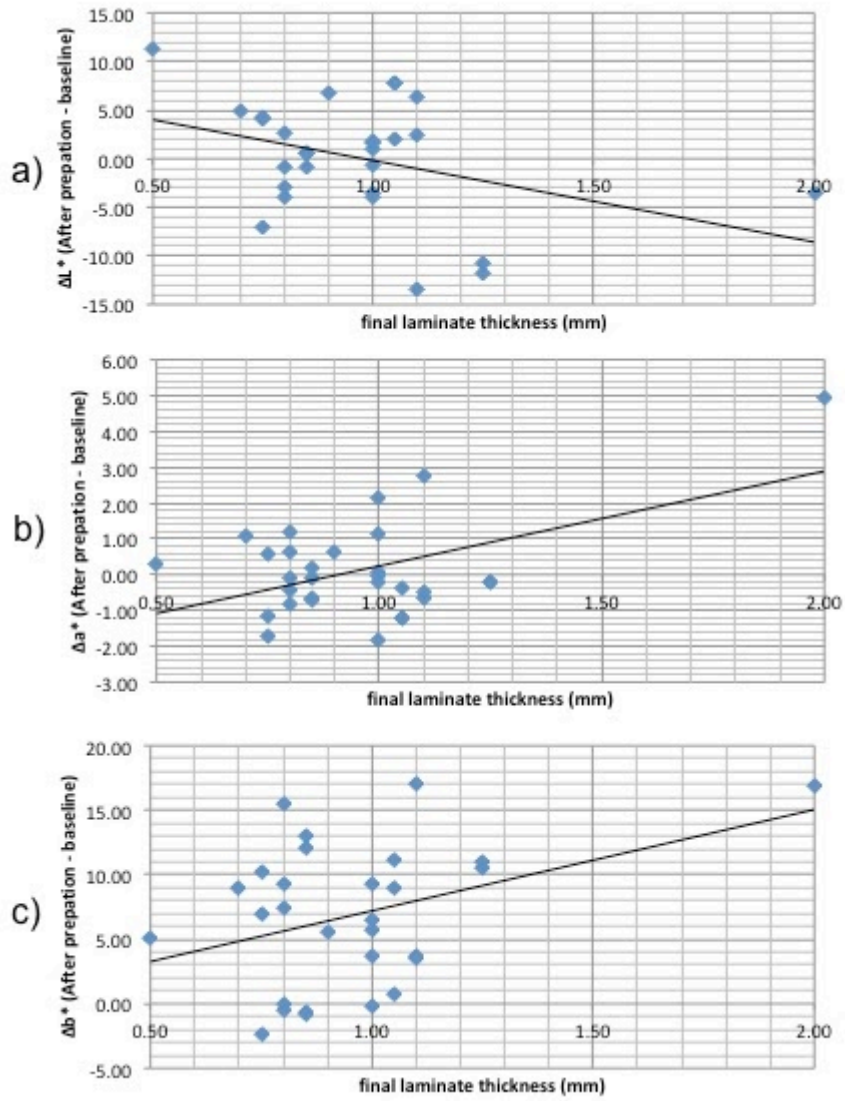

Figure 3. Pearson's correlation for the analysis considering after tooth preparation and baseline: a) ΔL*; b) Δa* and c) Δb*

For the analysis considering the VITA scores, the comparison for each measurement for each tooth is in Table 5. It can be seen that, for all comparisons, the final conditions (B1) result in color score statistically similar to the baseline (B1/A1) ($p<0.05$) for all teeth. The preparation result in color change statistically similar to baseline ($p<0.05$), but statistically different from the final conditions. There were no differences between the teeth ($p>0.05$).

Table 5. Median (minimum; maximum) of color values by scores (Vita).

	Time			
	Baseline	After Preparation	Finai 1	Final 2
Central incisors (CI)	2 (1; 15) ABa	2 (1; 16) Aa	1 (1; 2) Ba	1 (1; 2) Ba
Lateral incisors (LI)	1 (1; 15) Aa	2.5 (1; 12) Aa	1 (1; 2) Aa	1 (1; 2) Aa
Canines (C)	1.5 (1; 15) ABa	7.5 (1; 16) Aa	1 (1; 2) Ba	1 (1; 2) Ba
All teeth (CI, LI, C)	2 (1; 15) B	3 (1; 16) A	1 (1; 2) B	1 (1; 2) B

Considering ΔSGU, in Figure 4 shows that the variation took into consideration the final analysis and baseline resulted in a small value with statistically significant difference in relation to the variation between preparation and baseline ($p<0.05$).

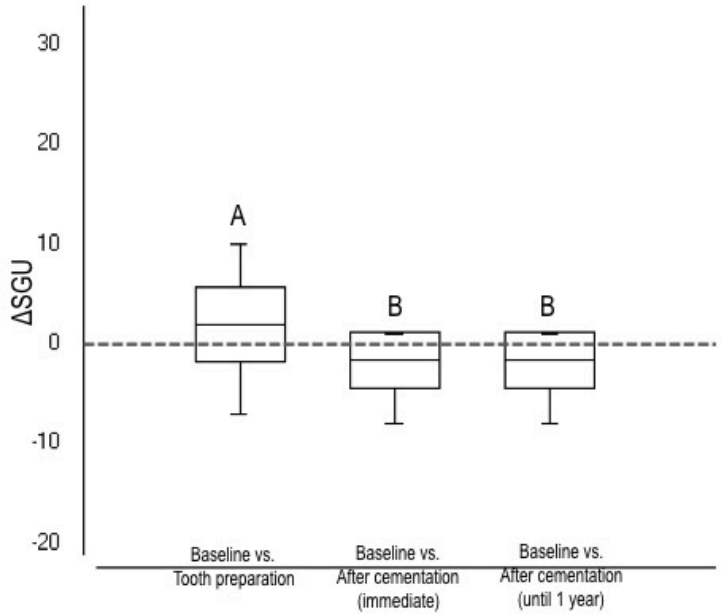

Figure 4. ΔSGU box plot show median, first and third quartiles, and minimum and maximum values considering all teeth. Different letter indicate statistical difference between measurements.

5 - Discussion

5 DISCUSSION

The present results support the rejection of the null hypothesis once it could be seen that the thickness and the tooth prepared had influence on the color change results. In general, this was expected once different tooth - central incisors, lateral incisors and canines - have differences in relation to the optical appearance (Falcone, Kelly et al. 2016). In relation to the thickness of the ceramic veneer, it has to take into account that the material itself has optical properties - color and translucency - which can modify the dental substrate. It was not the aim of the study, but important aspects to discuss the results were quietly standardized, as thickness and color of ceramic, kind and color of cement). To the best of author's knowledge, there are not available studies which perform the color variation in of the treatment with ceramic laminates in function of tooth prepared and/or ceramic thickness, which justify this study.

Regarding the color coordinate results, it can be seen that tooth preparation did not alter the variations in L*, a* and b*. Interesting, Δb* showed variation with the treatment with ceramic laminates (considering the final measurements and baseline). After treatment, a significant reducing in Δb* values were observed, presenting a change from positive to negative values, which indicate a dislocation in the direction

to blue color, making less yellow (Rosenstiel and Johnston 1988, Hallmann, Ulmer et al. 2019). Positive ∆a values indicate a reddish color (Rosenstiel and Johnston 1988). In general, in all situations, the value for this coordinate was low positive or negative, without significance when compared. In front of this, it can be inferred that this axis of the hue dimension of the color tooth was not altered with the treatment with ceramic laminates. The ∆L * showed significant differences in certain groups when the measures were compared. The L* coordinate are related to the white pigment in color, evidencing the luminosity. The comparisons showed slight variations in this coordinate, showing that the color alteration obtained was not related to the white color. In this study, this may be due to the fact that the initial condition of the tooth treated was around B1-A1 (scores 1-2 / See Table 5) and the final result was B1.

The clinical aspects of the treatment (Figure 1); which clearly shows the "lighter effect" of the ceramic veneers. In front of this, changes in L* was expected and just the b* axis showed alteration. As translucency permits the passage of light and also disperses light, it could be described as a state between complete opacity and transparency, the light being diffused rather than reflected or absorbed (Awad, Stawarczyk et al. 2015). As translucency has increased with thinner ceramics, the color match in porcelain laminate veneers has become more complicated (Turgut and Bagis 2013). Heffernan et al., concluded that the range of translucency in ceramics at clinically relevant thicknesses resulted from different crystalline compositions. As translucency intends the passage and the dispersion of light, it can be described as a state between complete opacity and transparency, the light being diffused rather than reflected or absorbed (Awad, Stawarczyk et al. 2015). As thinnest a ceramic laminate, more translucent it will be, affecting is color match ability (Turgut and Bagis 2013). In the present results, the thickness of the laminate was approximately 1 mm and mosth of the cemented substrates were enamel. In front of this, it can be assumed that the L* and a* values of the initial conditions of the teeth were sustained by the translucent veneers, which modified the hue characteristics of the substrate, changing the b* axis.

Even most of the teeth preparation been restricted to enamel, considering the Pearson's correlation and the Figure 3, it can be assumed that as thickest the

ceramic laminate thickest the enamel wear performed. This is clear, once the correlations were significant when considered the analysis between tooth preparation and baseline, showing that with more preparation, lesser luminosity and higher tendency for dislocation to the red (a*) and yellow (b*). The removing or reducing on enamel thickness, which is translucent, evidence the dentine, a chromed, saturated tissue (Falcone, Kelly et al. 2016). This important once, depending on the clinical situation, a lesses translucent (MT or LT) ceramic should be uses. In this study, just 20% of the teeth were not treated with high-trasnlucent ceramic. Faced with the obtained results, it can be stated that, when largest color variation is not necessary, the conservative preparations and the thinnest ceramic are applicable, once considering the correlations after the treatment, no differences were found. The ΔE is the CIE L*a*b* color formula (Paravina, Ghinea et al. 2015) used for most studies to evaluate color of tooth (Joiner and Luo 2017) and dental materials (Kamishima, Ikeda et al. 2005, Lim, Yu et al. 2010). The CIEDE2000 adjusted formula was developed to improve CIELab correction between the computed and perceived color (Gomez-Polo, Portillo Munoz et al. 2016). Both formulas were applied in this study to achieve comparability with previous results. Some studies report values in relation to these formulas correlating them with which are clinically perceptible. In according to the literature, variation higher than 3 are considered clinically perceptible (Johnston and Kao 1989, Gomez-Polo, Portillo Munoz et al. 2016). Color difference has been used extensively in dental research and applications, including the quantification of color change caused by processing dental materials (Ghinea, Perez et al. 2010).

The variations observed, as for ΔE e ΔE_{00} were always clinically perceptible. Considering all teeth, no differences were found in relation to the measurements (final X baseline / preparation X baseline). However, the canine itself showed a lower and significant variation when comparing the final condition in relation to preparation. Morphologically, the canines are considered tooth with more saturation due to its higher amount of dentine located at the buccal face (Falcone, Kelly et al. 2016). So, the canine preparation reduces the enamel thickness exposing the high saturated dentin. After laminate cementation, with bleached colors 90% and whither resin cements (90%) the color alteration in relation baseline is diminished, explained the statistical difference found for ΔE in these teeth. Considered the thickness of ceramic

used in this investigation, it can be concluded that a men of 0.9 mm thickness is adequate to recover a color of canines. It is important to bear in mind the ΔE formula is modular and it does not take into account if the variation is positive or negative, being important the analysis of the ΔL*, Δa* and Δb* coordinates apart. Regarding ΔE_{00}, no differences are found.

The evaluation considering the shade unit guides (ΔSGU) taking the VITA score accounts presented data of relevant issue, once the shade color guide if an important instrument of communication between clinician and patients; and between clinicians and technicians. The results showed that the preparation leads to the classification with more darkened scores, as pointed to the numeric results. Besides, the comparison between analysis clearly shows that the treatment achieve the whitening effect of the prepared tooth, once the scores at the final results (in relation to the baseline) were lesser and statistically significant when compared to the analysis between preparation and baseline. This is important once, visually, the proper patient is able to identify a difference, for example of a B1 and A1 conditions. For sure, if the results took into account the common bleached scale (Ivoclar Vivadent) used by clinicians and technicians, the differences would be extrapolated. It is reasonable once 90% of the teeth was treated with bleach colors of ceramic (BL4, BL3, BL2), which in a thinner veneer is translucent but present high value, beeing able to modify the final sensation of the esthetic treatment by the patients themselves.

Despite to not be the primary intention of the study, the results showed that the treatment with ceramic veneers presented color stability until 12-months follow-up. This is already stated in the literature and may be related to several factors, as the employment of veneers of high translucency and thinness (Turgut and Bagis 2013, Barizon, Bergeron et al. 2014), and color stability of the resin cement used (Lee and Choi 2018)

6 - Conclusion

6 CONCLUSION

The results of this study intends to conclude:

1. The treatment with ceramic laminates achieve perceptible color changes for all teeth when considering the variation in unit shade guide based in the VITA scores (ΔSGU), and for the canines, when considered the ΔE analysis.

2. There is a correlation between the thickness of the ceramic laminate and the color alteration after tooth preparation, considering the ΔL*, Δa* and Δb*.

3. The final color alteration produced by the treatment with thinner and translucent ceramic laminates is mainly related to the changes in b* axis.

4. There was no significant color change after 12 months.

References

REFERENCES

Awad D, Stawarczyk B, Liebermann A, Ilie N. Translucency of esthetic dental restorative CAD/CAM materials and composite resins with respect to thickness and surface roughness. **J Prosthet Dent.** 2015;113(6):534-40.

Bagis B, Turgut S. Optical properties of current ceramics systems for laminate veneers. **J Dent.** 2013;41 Suppl 3:e24-30.

Barghi N, Lorenzana RE. Optimum thickness of opaque and body porcelain. **J Prosthet Dent.** 1982;48(4):429-31.

Barizon KT, Bergeron C, Vargas MA, Qian F, Cobb DS, Gratton DG, et al. Ceramic materials for porcelain veneers: part II. Effect of material, shade, and thickness on translucency. **J Prosthet Dent.** 2014;112(4):864-70.

Brewer JD, Garlapo DA, Chipps EA, Tedesco LA. Clinical discrimination between autoglazed and polished porcelain surfaces. **J Prosthet Dent.** 1990;64(6):631-4.

Brielmann AA, Pelli DG. Aesthetics. **Curr Biol.** 2018;28(16):R859-R63.

Calamia JR, Calamia CS. Porcelain laminate veneers: reasons for 25 years of success. **Dent Clin North Am.** 2007;51(2):399-417, ix.

Czigola A, Abram E, Kovacs ZI, Marton K, Hermann P, Borbely J. Effects of substrate, ceramic thickness, translucency, and cement shade on the color of CAD/CAM lithium-disilicate crowns. **J Esthet Restor Dent.** 2019;31(5):457-64.

de Azevedo Cubas GB, Camacho GB, Demarco FF, Pereira-Cenci T. The Effect of Luting Agents and Ceramic Thickness on the Color Variation of Different Ceramics against a Chromatic Background. **Eur J Dent.** 2011;5(3):245-52.

Duran Ojeda G, Henriquez Gutierrez I, Guzman Marusic A, Baez Rosales A, Tisi Lanchares JP. A Step-by-Step Conservative Approach for CAD-CAM Laminate Veneers. **Case Rep Dent.** 2017;2017:3801419.

Falcone ME, Kelly JR, Rungruanganut P. In Vivo Color Relationships Between the Maxillary Central Incisors and Canines as a Function of Age. **Int J Prosthodont.** 2016;29(5):496-502.

Ghinea R, Perez MM, Herrera LJ, Rivas MJ, Yebra A, Paravina RD. Color difference thresholds in dental ceramics. **J Dent.** 2010;38 Suppl 2:e57-64.

Gomez-Polo C, Portillo Munoz M, Lorenzo Luengo MC, Vicente P, Galindo P, Martin Casado AM. Comparison of the CIELab and CIEDE2000 color difference formulas. **J Prosthet Dent.** 2016;115(1):65-70.

Hallmann L, Ulmer P, Gerngross MD, Jetter J, Mintrone M, Lehmann F, et al. Properties of hot-pressed lithium silicate glass-ceramics. **Dent Mater.** 2019;35(5):713-29.

Hammad IA, Stein RS. A qualitative study for the bond and color of ceramometals. Part I. **J Prosthet Dent.** 1990;63(6):643-53.

Hammad IA, Stein RS. A qualitative study for the bond and color of ceramometals. Part II. **J Prosthet Dent.** 1991;65(2):169-79.

Jacobs SH, Goodacre CJ, Moore BK, Dykema RW. Effect of porcelain thickness and type of metal-ceramic alloy on color. **J Prosthet Dent.** 1987;57(2):138-45.

Johnston WM, Kao EC. Assessment of appearance match by visual observation and clinical colorimetry. **J Dent Res.** 1989;68(5):819-22.

Joiner A, Luo W. Tooth colour and whiteness: A review. **J Dent.** 2017;67S:S3-S10.

Jorgenson MW, Goodkind RJ. Spectrophotometric study of five porcelain shades relative to the dimensions of color, porcelain thickness, and repeated firings. **J Prosthet Dent.** 1979;42(1):96-105.

Kamishima N, Ikeda T, Sano H. Color and translucency of resin composites for layering techniques. **Dent Mater J.** 2005;24(3):428-32.

Kelly JR, Nishimura I, Campbell SD. Ceramics in dentistry: historical roots and current perspectives. **J Prosthet Dent.** 1996;75(1):18-32.

Lee SM, Choi YS. Effect of ceramic material and resin cement systems on the color stability of laminate veneers after accelerated aging. **J Prosthet Dent.** 2018;120(1): 99-106.

Lim HN, Yu B, Lee YK. Spectroradiometric and spectrophotometric translucency of ceramic materials. **J Prosthet Dent.** 2010;104(4):239-46.

Meijering AC, Creugers NH, Roeters FJ, Mulder J. Survival of three types of veneer restorations in a clinical trial: a 2.5-year interim evaluation. **J Dent.** 1998;26(7):563-8.

O'Brien WJ, Kay KS, Boenke KM, Groh CL. Sources of color variation on firing porcelain. **Dent Mater.** 1991;7(3):170-3.

Paravina RD, Ghinea R, Herrera LJ, Bona AD, Igiel C, Linninger M, et al. Color difference thresholds in dentistry. **J Esthet Restor Dent.** 2015;27 Suppl 1:S1-9.

Peumans M, Van Meerbeek B, Lambrechts P, Vanherle G. Porcelain veneers: a review of the literature. **J Dent.** 2000;28(3):163-77.

Rosenstiel SF, Johnston WM. The effects of manipulative variables on the color of ceramic metal restorations. **J Prosthet Dent.** 1988;60(3):297-303.

Shokry TE, Shen C, Elhosary MM, Elkhodary AM. Effect of core and veneer thicknesses on the color parameters of two all-ceramic systems. **J Prosthet Dent.** 2006;95(2):124-9.

Shono NN, Al Nahedh HN. Contrast ratio and masking ability of three ceramic veneering materials. **Oper Dent.** 2012;37(4):406-16.

Soim A, Strimbu M, Burde AV, Culic B, Dudea D, Gasparik C. Translucency and masking properties of two ceramic materials for heat-press technology. **J Esthet Restor Dent.** 2018;30(2):E18-E23.

Turgut S, Bagis B. Effect of resin cement and ceramic thickness on final color of laminate veneers: an in vitro study. **J Prosthet Dent.** 2013;109(3):179-86.

Vichi A, Louca C, Corciolani G, Ferrari M. Color related to ceramic and zirconia restorations: a review. **Dent Mater.** 2011;27(1):97-108.

Witzel C, Gegenfurtner KR. Color Perception: Objects, Constancy, and Categories. **Annu Rev Vis Sci.** 2018;4:475-99.

Yilmaz K, Gonuldas F, Ozturk C. The effect of repeated firings on the color change of dental ceramics using different glazing methods. **J Adv Prosthodont.** 2014;6(6): 427-33.