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Impact of gray background on tooth color shade matching: a comparison of visual and instrumental methods

Impacto do fundo cinza na seleção de cor dental: uma comparação entre métodos visuais e instrumentais

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ABSTRACT

Objective: This study evaluates the impact of a gray background on visual tooth shade selection, focusing on various incisal translucency patterns in upper incisors. **Material and Methods:** Sixty-three clinicians assessed VITA 3D Master Shade Guide tabs representing right upper central incisors under different conditions, with or without a gray background. Translucency patterns (A, B, C) were considered, and standard tabs were defined using a clinical spectrophotometer. Statistical analyses, including repeated measures ANOVA and ordinal logistic regression, compared scores and agreement levels. **Results:** Darker tabs were selected for Case C, while Case B resulted in lighter tabs. A gray background increased lightness levels, enhancing agreement between visual and instrumental shade selection. Reduced agreements were noted in cervical areas and cases with higher incisal translucency. No significant difference was found among tooth thirds (p=.097). **Conclusion:** Using a gray background during tooth shade selection improved agreement between visual and instrumental shade selection. Incorporating this method can enhance tooth shade matching when relying on visual analysis. Introducing a cost-effective gray background can significantly improve agreement between visual and instrumental shade selection, addressing financial constraints associated with advanced tools. Clinicians can now implement a more reliable and accessible protocol, positively impacting the precision of esthetic restorations, especially in cases involving upper incisors.

KEYWORDS

Color; Color perception; Dental shade; Operative dentistry; Shade selection.

RESUMO

Objetivo: Este estudo avalia o impacto de um fundo cinza na seleção visual da cor do dente, com foco em vários padrões de translucidez incisal nos incisivos superiores. **Material e Métodos:** Sessenta e três clínicos avaliaram as guias VITA 3D Master Shade Guide representando os incisivos centrais superiores direitos sob diferentes condições, com ou sem um fundo cinza. Os padrões de translucidez (A, B, C) foram considerados, e as guias padrão foram definidas usando um espectrofotômetro clínico. As análises estatísticas, incluindo ANOVA de medidas repetidas e regressão logística ordinal, compararam os escores e os níveis de concordância. **Resultados:** Foram selecionadas abas mais escuras para o Caso C, enquanto o Caso B resultou em abas mais claras. Um fundo cinza aumentou os níveis de luminosidade, melhorando a concordância entre a seleção visual e instrumental da tonalidade. Foram observadas concordâncias reduzidas nas áreas cervicais e nos casos com maior translucidez incisal. Nenhuma diferença significativa foi encontrada entre os terços dos dentes (p=.097). **Conclusão:** O uso de um fundo cinza durante a seleção da cor do dente melhorou a concordância entre a seleção visual e instrumental da cor.

A incorporação desse método pode melhorar a correspondência da cor do dente quando se depende da análise visual. A introdução de um fundo cinza de baixo custo pode melhorar significativamente a concordância entre a seleção visual e instrumental da cor, abordando as restrições financeiras associadas a ferramentas avançadas. Os clínicos podem agora implementar um protocolo mais confiável e acessível, impactando positivamente a precisão das restaurações estéticas, especialmente em casos envolvendo incisivos superiores.

PALAVRAS-CHAVE

Cor; Percepção de cores; Cor dental; Dentística; Seleção de cor.

INTRODUCTION

Tooth shade selection is a critical step in esthetic restorative dentistry, which can be performed either visually, by comparing the tooth color with shade guide tabs, or instrumentally through the use of a clinical spectrophotometer, digital scanner, or standardized photographs [1]. While instrumental analysis tends to be more precise, it should ideally be combined with visual methods to ensure accuracy [2-8]. However, many of the devices required for instrumental shade measurement are expensive and may not be accessible for most clinicians. As a result, feasible clinical protocols that enhance the accuracy of visual shade selection are needed [9]. Furthermore, successful visual shade selection depends on several clinician-related factors, such as professional experience and visual acuity [10-14]. In addition, external factors like lighting conditions, background, and the surrounding area also influence the accuracy of the shade selection [15-18].

Several protocols have been proposed to improve the reliability of visual shade analysis. In addition to standardizing lighting conditions, factors such as the time spent during shade analysis and the impact of contrast effects, such as lipstick, have been shown to influence shade accuracy [16,19-23]. Achieving esthetic restorations requires the accurate reproduction of all details observed in natural tooth structures [24,25]. One such detail, especially in younger patients, is incisal translucency, which plays a crucial role in esthetic outcomes and poses significant challenges for clinicians [26].

The use of dark backgrounds is common in dental photography, as it enhances the visibility of important features, such as the incisal borders, which can be useful during shade selection [27]. Alternatively, backgrounds like gray, pink, or blue have been suggested to heighten sensitivity to the teeth's yellowness and reduce the need for repeated comparisons [15]. Gray backgrounds, in particular, are frequently used to minimize background reflection during shade measurement [2]. Despite these established practices, the specific role of incisal translucency in shade matching—particularly in the context of using a gray background—has not been thoroughly investigated.

In clinical situations, background color, translucency degree, and the surrounding area (such as lips or adjacent teeth) can all affect visual shade matching [16,28]. Therefore, this study aims to evaluate the influence of using a gray background on dental shade selection in upper incisors with varying patterns of incisal translucency. We hypothesized that the use of a gray background would enhance visual shade matching, with its effectiveness varying depending on the degree of incisal translucency.

MATERIAL AND METHODS

This study evaluated the independent variables 'background condition' (no background and gray background), the pattern of incisal translucency (three cases from three different young female adults), and the 'tooth third' (cervical, middle, and incisal). The dependent variables were shade tabs (classified in scores and lightness level) selected by the evaluators and the agreement rate with those tabs determined by the clinical spectrophotometer. The local ethics committee approved the study (N.565,812/2014). The patients who had their teeth evaluated and all evaluators signed informed written consent.

This study followed a within-subject design, with each subject serving as their own control. The shade of the right maxillary central incisors was evaluated under two conditions: no background (control) and with an 18% gray background. Visual shade selection was performed by 63 evaluators, followed by instrumental analysis

using a spectrophotometer. The cases (A, B, and C) were selected to represent different patterns of incisal translucency to explore how translucency impacts shade matching accuracy. The sequence of evaluations was designed to minimize bias, with evaluators assessing the shade without a background first, followed by a second evaluation with the gray background after seven days.

In this study, we evaluated the shade of the right maxillary central incisors of three subjects. The anterior teeth of patients included did not have carious or non-carious lesions or restorations. The teeth were maintained in a normal moisture state during both visual and instrumental shade selection, and it was requested that the patients any type of lipstick. The incisal edges of the incisors presented different patterns among the patients (Figure 1). The translucency patterns of incisors evaluated were classified as the following: Case – indeterminable; Case B - restricted to the more incisal area; and Case C - present in both proximal and incisal areas [29]. Two weeks before the shade measurements, each subject received periodontal treatment and dental prophylaxis. All three subjects presented good oral health during the entire study.

For the instrumental analysis, an instrumental shade selection was performed using a clinical spectrophotometer (VITA Easyshade Advance 4.0; VITA Zahnfabrik). The tab on the VITA 3D-Master shade guide (VITA Easyshade Advance 4.0; VITA Zahnfabrik) indicated by the spectrophotometer for each crown third was recorded three times and defined as the standard. The device tip was placed perpendicularly to the buccal surface. The measurements were performed with and without an 18% gray background (Flexipalette Color Match, Smile Line) placed behind the upper teeth.

For the visual analysis, sixty-three trained clinicians (31 men and 32 woman) with normal color vision that passed color matching competency tests (Ishihara and Farnsworth-Munsell 100 hue) visually selected the shade tabs corresponding to teeth color. The visual shade selection was performed for each tooth third using or not the gray background under artificial daylight CIE D65 standard illuminant. After a brief adaptation period, shade selection was completed within three minutes to avoid visual fatigue [30]. In the first evaluation, the evaluators selected shade tabs without the gray

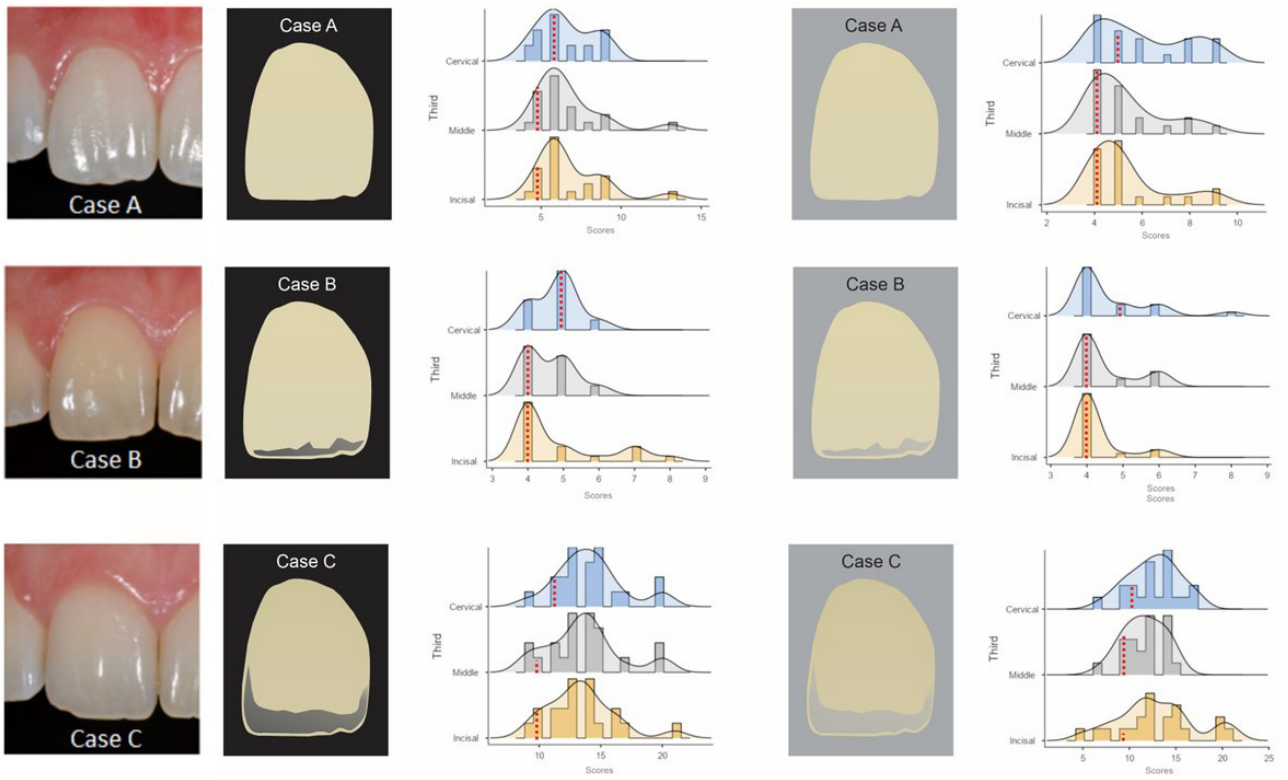

Figure 1 - Tooth color analysis cases categorized by translucency: (A) indeterminable; (B) restricted to more incisal area; and (C) present in both proximal and incisal areas. Histograms display scores based on VITA 3D Master shade guide tabs selected by evaluators on the right side of representative cases. Red vertical dashed lines correspond to scores attributed to tabs by the spectrophotometer (used as standard).

background. The same evaluators repeated the shade selection with the gray background placed behind the upper teeth after a seven-day interval. This gap was implemented to minimize the possibility of recall bias. Evaluators were also blinded to the specific focus of the study, ensuring that each condition was assessed independently.

For each measurement, the agreements between the visual and instrumental shade analysis were calculated. Agreements were defined when the evaluator selected the same shade tab indicated by the spectrophotometer. A second agreement analysis was done based on the same lightness level, even when the shade tab differed. Moreover, each tab selected by the evaluators were scored according the following rank (from the lightest to the darkest): 1 - 0M1, 2 - 0M2, 3 - 0M3, 4 - 1M1, 5 - 2M1, 6 - 1M2, 7 - 2R1.5, 8 - 2L1.5, 9 - (3M1 or, 2M2), 10 - 2R2.5, 11 - 2L2.5, 12 – [3R1.5 or, 3L1.5], 13 - 2M3, 14 - 3M2, 15 - 3L2.5, 16 -(3M3, 3R2.5), 17 - 4L1.5, 18 -19 - 4M1, 20 - 4R1.5, 21 - 4M2, 21 - (5M1 or, 4L2.5), 22 - 4R2.5, 23 - 4M3, 24 - 5M2, 25 - 5M3 [31].

Repeated-measures ANOVA analyzed score data. The independent variables analyzed were 'case', 'background', and 'tooth third', while the last two variables were defined as repetition factors. Pair-wise comparisons were performed with Tukey's test. The lightness level (first number) of each tab selected by the evaluators was also evaluated. These data were analyzed using an ordinal Logistic Regression, and the predictors were 'case', 'background', and 'tooth third'.

For each experimental condition (case vs. tooth third), the scores and lightness values from shade tabs measured with the spectrophotometer Easyshade were compared with those selected by the evaluators. Data of agreements were analyzed using binomial logistic regressions. A significance level of 95% was pre-set for all analyses.

RESULTS

Figure 1 shows the distribution of scores determined for the tabs selected by evaluators according to the case, crown third, and background used during the evaluation. Repeated-measures ANOVA showed that only the independent variables 'background' ($P<.001$) and 'case' ($P<.001$) affected the scores of tabs selected. No difference was observed among the 'tooth third' ($P=.097$). All interactions were statistically insignificant ($P>.050$). The results are presented in Table I. The highest scores (darkest tabs) were selected for case C, and the lowest (lightest tabs) for case B. In general, lighter tabs were selected using a gray background.

Results of the ordinal logistic regression are shown in Table II. The third did not affect the lightness level selected by the evaluators. The lightest levels were observed using the gray background than with the control.

Results of the binomial logistic regressions are shown in Table III. For the tab scores, shade selection in the incisal third presented higher odds to agree with the spectrophotometer than the cervical, which did not differ from the middle third. The lowest agreements were observed for case C, while similar values were found between cases A and B. The gray background increased the odds (5-fold) of obtaining agreement between the evaluators and the spectrophotometer data. When the lightness values were analyzed, the tooth third did not affect the odds of agreement between the evaluators and the spectrophotometer data. Case B increased the odds of agreement when compared to case A. The use of gray background increased in 2-fold the odds of agreement.

Table I - Means (standard deviations) of scores attributed to tabs selected by evaluators in VITA 3D Master shade guide according to case, background, and tooth third (n=20)

Backgrounds		Control			Gray card			Pooled average
Thirds		Cervical	Middle	Incisal	Cervical	Middle	Incisal	
Case	A	6.5 (1.7)	6.6 (2.0)	6.8 (2.1)	6.0 (1.9)	5.3 (1.6)	5.4 (1.6)	6.1 (1.9) [B]
	B	4.8 (0.6)	4.6 (0.7)	4.9 (1.3)	4.7 (1.1)	4.5 (1.6)	4.3 (0.6)	4.6 (0.9) [C]
	C	14.1 (2.8)	13.6 (3.0)	13.4 (2.8)	12.6 (2.7)	11.6 (2.2)	12.9 (4.3)	13.0 (2.8) [A]
Pooled average			8.4 (4.4) [a]			7.5 (4.1) [b]		

For pooled averages, superscript distinct letters indicate statistical difference ($p<.05$). The overall agreement between the backgrounds was 32.2% (Cohen kappa coefficient: 0.228).

Table II - Ordinal logistic regression results estimating lightness level of tab selected by evaluators in VITA 3D Master shade guide

Predictor		Estimate	Standard error	*P*-value
Root third				
	Cervical (ref.)	1.000		
	Middle	- .416	.264	.115
	Incisal	-.338	.265	.201
Background				
	Control (ref.)	1.000		
	Gray	-.588	.217	.010
Case				
	A (ref.)	1.000		
	B	-1.326	.278	<.001
	C	3.712	0.413	<.001

Table III - Binomial logistic regression results estimating odds of agreement between shade selected by evaluator and that measured using spectrophotometer Easyshade

Predictor		Scores*			Lightness		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
Root third							
	Cervical (ref.)	1.00			1.00		
	Middle	2.03	.99 - 4.16	.052	1.29	.76 – 2.18	.349
	Incisal	2.15	1.05 – 4.38	.036*	1.16	.68 – 1.95	.592
Background							
	Control (ref.)	1.00			1.00		
	Gray	5.01	2.71 – 9.27	<.001*	2.03	1.32 – 3.12	.001*
Case							
	A (ref.)	1.00			1.00		
	B	1.80	.97 – 3.35	.063	2.32	1.37 – 3.92	.002*
	C	.30	.13 – .68	.004*	.868	.52 – 1.46	.595

* Scores attributed to shade tabs selected. OR: odds ratio; CI: confidence interval.

Probabilities of agreements according to the background are presented in Figures 2 (scores) and 3 (lightness).

DISCUSSION

The study`s hypothesis was accepted. Neutral gray 18% is a neutral color that does not distort the other colors since it is halfway between black and white. Therefore, it is expected that a neutral background does not draw attention to itself and can neutralize the possible influence of lips, tongue, and gums on the shade selection process.

Different background colors have been evaluated, seeking to improve the tooth shade selection. It is stated that a white background would simulate the color of an opposite tooth, a pink would mimic the lips and oral mucosa, and a black would increase the contrast [2,12,15,16]. The same tooth observed in a white background and a dark background can be visualized in different shades due to changes in absorption and reflection of specific wavelengths [25]. It is reasonable to state that the background contrast would affect the shade selection in the incisal thirds of the anterior teeth due to its higher translucency [25]. However, the lowest levels of agreement were observed for case C, which presented translucencies in both proximal and incisal areas. This could be due to the more complex optical properties of these regions, as translucency increases light scattering and absorption, making shade matching more

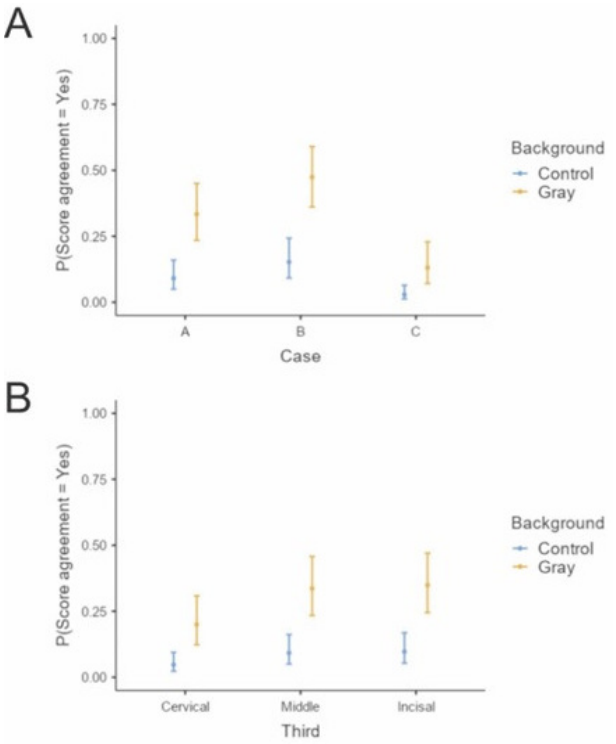

Figure 2 - Probabilities (p) and 95% confidence intervals of agreement between scores for shade tabs selected by evaluators and those measured using the spectrophotometer. Effect of background in relation to case (A) or root third (B) on probabilities.

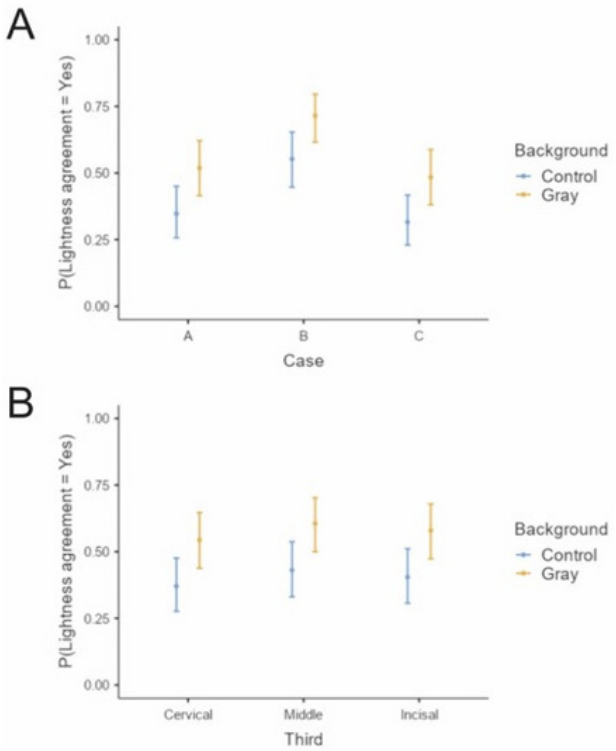

Figure 3 - Probabilities (p) and 95% confidence intervals of agreement between lightness of shade tabs selected by evaluators and those measured using the spectrophotometer. Effect of background in relation to case (A) or root third (B) on probabilities.

difficult. These findings align with prior research that suggests highly translucent areas pose a challenge for accurate shade matching [25]. The present study did not find any effect of the crown third on the level of agreement between visual and instrumental analyses.

Inaccurate shade selection can significantly compromise the aesthetic outcomes of restorative procedures [1]. A prior clinical study observed some shade mismatch between the ceramic restorations and surrounding teeth, ranging from 44 to 63% [24]. Therefore, a more precise and accurate shade matching avoids restoration replacement for aesthetic reasons and can reduce the cost of treatment. Still, controversial whether gender can or not intervene in the accuracy of tooth shade selection [6,12-14,21]. In the present study, however, the interference of evaluator gender on the visual tooth shade selection was not evaluated. To avoid a possible bias of this kind, we selected a similar number of male and female evaluators to participate in the current study.

During dental clinical routine, tooth shade selection is often done without any specific background. Some contrast allowing to visualize details in incisal edge is only achieved due to the darkness of the oral cavity. Interposing the lower lip between the upper and lower incisors has been suggested to improve shade selection, but it is not a standardized method [16]. Another approach to improve the shade selection is using a colored paper background [15]. In the present study, the use of a gray background during the tooth shade selection increased the odds of agreement between the visual and instrumental shade tab selection.

Using a gray background increased the odds of obtaining agreement between the evaluators and the spectrophotometer data. Regarding the tabs/scores, using the gray background increased 5-fold the odds of agreement, while a 2-fold increase was observed for agreement on lightness. In general, darker tabs were selected by the evaluators in the absence than using the gray background. Considering that background color is supposed to affect only the more incisal area shade, these results are probably related to the effect of the surrounding area on the color perception [16,28]. Interestingly, the lowest agreements were observed in the cervical third, even though the effect of the surrounding color is expected to be less pronounced there.

Advances in color measuring devices, such as a spectrophotometer, may improve the

reliability of shade matching and communication for reproducibility [7]. However, clinicians commonly rely on visual shade analysis, and practical protocols that enhance the accuracy of shade selection can be very beneficial. The findings in the present study clearly showed that simply placing a gray background behind the teeth during the shade selection improved the agreement of the selected tab with that indicated by the clinical spectrophotometer. It is important to emphasize, however, that the chance of agreement was usually lower than 50% even when the gray background was used. Despite the spectrophotometer data being used as a standard, the accuracy of this device to properly determine the correct shade was demonstrated to be approximately 78% [9]. The present study had a limitation in that the sequence of shade evaluation, with or without the gray background, was not randomized. Indeed, the first evaluation was always carried out without the use of the gray background, which could have induced an unknown bias in the study.

CONCLUSIONS

A gray background significantly improved the agreement between visual shade selection and instrumental measurements using a clinical spectrophotometer, especially in the incisal crown third. However, this agreement decreased in areas with incisal translucency involving proximal and incisal regions. The use of a gray background offers a cost-effective method to enhance the precision of visual shade matching, making it a more accessible alternative to advanced color selection tools, by improving the accuracy of esthetic restorations.

Author's Contributions

Walleska Feijó Liberato (DDS, MS, PhD):Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Project Administration, Writing – Original Draft Preparation. Vinicius Salgado (DDS, MS, PhD):Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft Preparation. Marco Antonio Gallito (DDS, MS, PhD):Writing – Original Draft Preparation, Supervision, Validation, Visualization. André Luis Faria-e-Silva (DDS, MS, PhD):Data Curation, Formal Analysis, Writing – Original Draft Preparation, Validation. Luis Felipe Jochims Schneider (DDS, MS, PhD):Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Supervision, Writing – Original Draft Preparation, Validation, Visualization. Larissa Maria Assad Cavalcante (DDS, MS, PhD):Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Supervision, Writing – Original Draft Preparation, Validation, Visualization.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies. Approval number (N.565,812/2014). The patients who had their teeth evaluated and all evaluators signed informed written consent. CAAE: 24173414.0.0000.5243.

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