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JOSÉ CAETANO SILVA FERREIRA

INFLUÊNCIA DA TÉCNICA E DO NÍVEL DE CONHECIMENTO NA
CORRESPONDÊNCIA DA ESCOLHA DE CORES EM ODONTOLOGIA

UBERABA-MG

2026

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Dissertação apresentada ao Programa de Pós-graduação em Odontologia – Mestrado Acadêmico da Universidade de Uberaba, como requisito para obtenção do título de Mestre em Odontologia.

Área de concentração: Clínica Odontológica Integrada.

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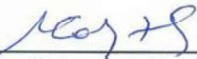
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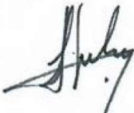
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“A cor revela que, na odontologia, ciência e sensibilidade são inseparáveis.”

RESUMO

Avaliar se a seleção convencional de cor utilizando os sistemas VITA Classical® e VITA 3D-Master®, realizada por estudantes de Odontologia com diferentes níveis de experiência clínica, corresponde aos valores de cor obtidos por meio de um espectrofotômetro digital. Este estudo observacional transversal incluiu 80 estudantes de Odontologia (do período pré-clínico até 1,5 anos de experiência clínica) e 80 pacientes com idade entre 18 e 40 anos, apresentando incisivo central superior hígido. O estudo foi aprovado pelo Comitê de Ética em Pesquisa da Universidade de Uberaba, sob CAAE nº 81813024900005145. Os estudantes realizaram a seleção de cor sob luz ambiente e sob iluminação odontológica padronizada (20.000 lx, 5500 K). Um pesquisador mascarado obteve medições triplicadas da cor utilizando o Vita Easyshade Advance 4.0. A concordância entre os métodos visual e digital foi avaliada por meio do coeficiente Kappa quadrático ponderado. A ANOVA de dois fatores, com teste post-hoc de Tukey, foi utilizada para comparar diferenças conforme a experiência do estudante, condição de iluminação e escala de cor ($\alpha = 0,05$). A concordância com o espectrofotômetro aumentou consistentemente com a experiência clínica. Sob luz ambiente, ambas as escalas de cor apresentaram melhora, passando de concordância leve entre estudantes inexperientes para concordância moderada entre aqueles com 1,5 anos de experiência. Sob iluminação odontológica, os valores de concordância foram, em geral, menores, sendo que o sistema VITA Classical apresentou o melhor desempenho entre os estudantes mais experientes. A experiência clínica melhora substancialmente a precisão da seleção visual de cor, sendo a luz ambiente uma condição mais confiável do que a iluminação do refletor odontológico. A escala VITA Classical demonstrou maior consistência nas avaliações, enquanto a espectrofotometria permanece como o método mais confiável para minimizar a subjetividade na seleção de cor.

Palavras-chave: Cor; Materiais Dentários; Espectrofotômetros.

ABSTRACT

Objective: To evaluate whether conventional shade selection using the VITA Classical® and VITA 3D-Master® systems, performed by undergraduate dental students with varying clinical experience, corresponds with shade values obtained using a digital spectrophotometer. **Methods:** This observational cross-sectional study included 80 dental students (preclinical to 1.5 years of clinical experience) and 80 patients aged 18–40 years with a sound maxillary central incisor. The study was approved by the Research Ethics Committee of the University of Uberaba, under CAAE n° 81813024900005145. Students performed shade selection under ambient light and under standardized dental lighting (20,000 lx, 5500 K). A blinded researcher obtained triplicate shade measurements using the Vita Easyshade Advance 4.0. Agreement between visual and digital methods was assessed using weighted quadratic Kappa coefficients. Two-way ANOVA with Tukey’s post-hoc test compared differences according to student experience, lighting condition, and shade guide ($\alpha = 0.05$). **Results:** Agreement with the spectrophotometer increased consistently with clinical experience. Under ambient light, both shade guides showed improvement from slight agreement among inexperienced students to moderate agreement among those with 1.5 years of experience. Under dental lighting, agreement values were lower overall, with the VITA Classical showing the best performance among experienced students. **Conclusions:** Clinical experience substantially improves the accuracy of visual shade matching, with ambient light offering more reliable conditions than operatory lighting. The VITA Classical guide demonstrated greater consistency across evaluations, while spectrophotometry remains the most dependable method for minimizing subjectivity in shade selection.

Keywords: Color; Dental Materials; Spectrophotometers.

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1 INTRODUÇÃO

A cor é uma sensação psicofísica em que ocorre a percepção visual da luz refletida por um objeto, sendo influenciada pelo observador, a fonte de luz, plano de fundo e pelo formato do objeto (Klinke *et al.*, 2023). As propriedades ópticas dos dentes são caracterizadas pela composição do esmalte e da dentina, assim como pela combinação dos efeitos da coloração extrínseca e intrínseca daqueles tecidos duros. O esmalte possui estrutura altamente mineralizada e pouco conteúdo orgânico, conferindo propriedades de transparência e opalescência. Em contrapartida, a dentina contém maior quantidade de conteúdo orgânico e menos mineral, o que a torna menos translúcida, permitindo maior reflexão da luz (Hakami *et al.*, 2023).

A satisfação e a aceitação do paciente que recebe um tratamento de reabilitação oral estão intimamente relacionadas à aprovação pessoal e às expectativas positivas em relação ao resultado do tratamento. Isto diz respeito não apenas à obtenção da funcionalidade adequada dos dentes, mas também à aparência estética. Neste contexto, a correta determinação da cor para a realização das restaurações dentárias e das próteses fixas ou removíveis desempenha um papel fundamental no sucesso da reabilitação oral. A determinação da tonalidade de cor dos dentes e/ou materiais restauradores é necessária para a reprodução e caracterização das restaurações, representando um desafio diário para os profissionais da prática odontológica (Prause *et al.*, 2024). Somado a isso, a estimativa da idade é um grande desafio nos laboratórios de antropologia e odontologia forense, bem como no âmbito judicial, como uma das ferramentas utilizadas na identificação humana. Nesse sentido, a literatura mostra que a análise de cor dos dentes pode auxiliar na estimativa de idade de um indivíduo (Martin-Martin *et al.*, 2024).

A cor possui três dimensões: o matiz, o croma e o valor. O matiz corresponde ao nome real da cor e pode ser interpretado como a tonalidade ou cor base do dente. O croma representa a saturação ou intensidade do matiz, varia com a quantidade de pigmento incorporado em um matiz e determina a intensidade da cor. O valor, descrito como uma escala de cinza (de branco a preto), representa a luminosidade do objeto, ou seja, da quantidade de energia luminosa que o objeto reflete ou transmite (Borse & Chaware, 2020). A seleção de cor é a capacidade do operador de conseguir correlacionar as cores reais da dentição natural com as dos materiais restauradores. Contudo, essa seleção exige conhecimento e concentração, pois diversos fatores, como a fonte de luz, o ambiente e as escalas de cor, podem influenciar

na precisão da cor (Santos *et al.*, 2021). Dessa forma, o cirurgião-dentista deve dispor de conhecimento, experiência e das melhores técnicas para selecionar a cor durante a reconstrução de um dente ou de uma reabilitação oral mais complexa.

A reprodução da cor dos dentes é um grande desafio na prática clínica. Existem diferentes métodos para a determinação da cor dos dentes e materiais restauradores, sendo o mais utilizado a escala de cores, que é composta por amostras representativas das médias das cores presentes na dentição humana, como a VITA Classical® e VITA 3D-Master Shade Guide® (VITA Zahnfabrik, Bad Säckingen, Alemanha) (Jouhar, 2024). A escala de cores VITA Classic® baseia-se no matiz e croma, em que o matiz possui as nuances de A (castanho), B (amarelo), C (cinza) e D (vermelho), enquanto o croma é dividido em 4 graus, variando de 1 a 4 (mais claro ao mais escuro). Contudo, a desvantagem desta escala é ser baseada apenas no matiz e croma, não contendo o valor, que é essencial para uma correta seleção de cor. Somado a isso, as escalas são geralmente mais amarelas do que a dentição natural e oferecem poucas opções de cores claras para dentes naturais de altos valores. Outra desvantagem relatada é que a escala VITA Classical® não apresenta tonalidades de cores mais escuras como as dos dentes de pacientes idosos, como também não abrange a coloração pósclareamento dos dentes (Dias *et al.*, 2023). Para reduzir essas dificuldades, a escala VITA 3D-Master Shade System® foi desenvolvida para ampliar a cobertura do espaço cromático utilizando as três dimensões, ou seja, matiz, croma e valor. Essa escala possui 26 cores e as divide em 5 grupos segundo a luminosidade da cor (valor). Nos grupos de valor 2, 3 e 4 existem três amostras cromáticas que representam o matiz e são divididas por letras, M (médio), L (amarelo) e R (vermelho). O uso dessa escala, basicamente, inicia-se definindo o grupo que possui o valor mais semelhante ao respectivo dente. Realiza-se a seleção do croma, comparando as diferentes saturações na coluna central do grupo e, em seguida, seleciona-se o matiz (Alvarado-Lorenzo *et al.*, 2024). Por ser mais antiga, apresentar uma menor quantidade de tonalidades de cor e ser utilizada pela maioria dos fabricantes de resina composta, a escala VITA Classic® é a mais utilizada nos consultórios odontológicos (Borse & Chaware, 2020).

Na busca pela objetividade, medições instrumentais da cor dos dentes usando espectrofotômetros, colorímetros e espectrorradiômetros são recomendadas em conjunto com abordagens visuais. Estes equipamentos atuam emitindo luz e avaliando o espectro refletido pelos dentes, identificando as cores presentes. O espectrofotômetro é um instrumento preciso para selecionar a cor, pois são capazes de detectar pequenas diferenças entre as cores que não são captadas pelo olho humano, contribuindo para a diminuição da subjetividade e dos erros

no procedimento (Alvarado-Lorenzo *et al.*, 2024). Os espectrofotômetros apresentam como vantagens desses métodos para determinar a cor de um dente, como a ausência do cansaço do profissional, padronização da iluminação e obtenção de ótimos resultados. Os erros acontecem ficam limitados à falta de treinamento/calibração do equipamento (Akl *et al.*, 2023).

Alguns estudos sugerem que a proficiência na correspondência de tonalidades está intrinsecamente ligada à idade, experiência e deficiências congênitas na visão de cores. A influência da experiência profissional, adquirida através de experiências clínicas, é evidente entre os profissionais de odontologia que realizam regularmente procedimentos restauradores, embora alguns estudos apresentem visões conflitantes sobre o significado da experiência (Jouhar *et al.*, 2022; Klinke *et al.*, 2023;). Haddad *et al.* (2011) demonstraram a influência da idade e do sexo na correspondência da cor dos dentes onde os participantes do sexo feminino alcançaram resultados significativamente melhores na diferenciação da cor dos dentes do que os participantes do sexo masculino. Eles também sugeriram que o nível de experiência não desempenha um papel crucial na correspondência de cores. Por outro lado, Jouhar (2022) concluiu que a experiência clínica foi fundamental para a escolha correta de cor dos dentes naturais, artificiais e materiais restauradores. Ristic *et al.* (2024) também afirmaram que os participantes alcançaram resultados significativamente melhores na correspondência de cores dos dentes após participarem de um curso sobre a escolha de cores dos dentes. Os espectrofotômetros proporcionam um aumento de 33% na precisão da escolha da cor de um dente, quando comparado às técnicas convencionais. Porém, os espectrofotômetros não são amplamente utilizados na prática clínica devido ao seu alto custo (Hina *et al.*, 2024).

Nas últimas décadas houve aumento da demanda por restaurações estéticas. No passado, as restaurações feitas de ouro, eram vistas como um símbolo de status e eram populares entre muitos pacientes, mas agora o objetivo é conseguir uma aparência natural que mimetize os dentes do paciente. Isto significa que os dentes restaurados devem ser precisos em termos de forma, translucidez, textura e tonalidade para criar um resultado esteticamente agradável. Por isso, é cada vez mais importante realizar treinamento com alunos de graduação e Cirurgiões-Dentistas sobre esta etapa importante do tratamento. Além disso, agregar a Odontologia digital à rotina de consultórios e clínicas tem se tornado positivo para conferir maior versatilidade, rapidez e precisão nos atendimentos (Gawali *et al.*, 2024). Dessa maneira, torna-se importante verificar se os novos equipamentos realmente agregam valor aos atendimentos, e se os custos de aquisição desses equipamentos se justificam, a fim de

aprimorar o tratamento dos pacientes. Através desta pesquisa, pode-se contribuir com informações valiosas para a odontologia clínica, que ajudarão na seleção da cor dentária e aprimorarão as melhores práticas de ensino em odontologia estética.

2 OBJETIVOS

Avaliar o método convencional de escolha de cor (escala VITA Classical® e VITA 3D-Master Shade System®), sob condições de luz ambiente e de um refletor odontológico, realizado por alunos de graduação em Odontologia da Universidade de Uberaba (UNIUBE), com diferentes níveis de experiência clínica e compará-lo com os valores obtidos por espectrofotômetro digital.

3 ARTIGO

ABSTRACT

Objective: To evaluate whether conventional shade selection using the VITA Classical® and VITA 3D-Master® systems, performed by undergraduate dental students with varying clinical experience, corresponds with shade values obtained using a digital spectrophotometer. **Methods:** This observational cross-sectional study included 80 dental students (preclinical to 1.5 years of clinical experience) and 80 patients aged 18–40 years with a sound maxillary central incisor. The study was approved by the Research Ethics Committee of the University of Uberaba, under CAAE n° 81813024900005145. Students performed shade selection under ambient light and under standardized dental lighting (20,000 lx, 5500 K). A blinded researcher obtained triplicate shade measurements using the Vita Easyshade Advance 4.0. Agreement between visual and digital methods was assessed using weighted quadratic Kappa coefficients. Two-way ANOVA with Tukey's post-hoc test compared differences according to student experience, lighting condition, and shade guide ($\alpha = 0.05$). **Results:** Agreement with the spectrophotometer increased consistently with clinical experience. Under ambient light, both shade guides showed improvement from slight agreement among inexperienced students to moderate agreement among those with 1.5 years of experience. Under dental lighting, agreement values were lower overall, with the VITA Classical showing the best performance among experienced students. **Conclusions:** Clinical experience substantially improves the accuracy of visual shade matching, with ambient light offering more reliable conditions than operatory lighting. The VITA Classical guide demonstrated greater consistency across evaluations, while spectrophotometry remains the most dependable method for minimizing subjectivity in shade selection.

Keywords: Color; Dental Materials; Spectrophotometers.

INTRODUCTION

Color is a psychophysical phenomenon in which the visual perception of light reflected from an object is influenced by multiple factors, including the observer, the light source, the background, and the geometric characteristics of the object (1). The optical properties of teeth are determined by the composition and structural interplay of enamel and dentin, together with the combined effects of intrinsic and extrinsic discoloration. Enamel, characterized by its highly mineralized structure and low organic content, exhibits translucency and opalescence, whereas dentin contains a higher proportion of organic material and less mineral content, resulting in reduced translucency and increased light reflection (2).

Patient satisfaction and acceptance of oral rehabilitation procedures are strongly associated with personal approval and positive expectations regarding treatment outcomes. These expectations pertain not only to functional recovery but also to the achievement of esthetically pleasing results. Accurate shade selection is therefore fundamental for the success of direct and indirect restorations, as well as for fixed and removable prostheses (3). Determining the shade of teeth and restorative materials is essential for reproducing and characterizing restorations, yet it remains a daily challenge for dental practitioners. Additionally, dental color analysis has gained relevance in forensic odontology and anthropology, where tooth shade has been investigated as a potential indicator of chronological age (4).

Tooth color is defined by three dimensions: hue, chroma, and value. Hue corresponds to the basic color family of the tooth; chroma represents the degree of saturation of that hue; and value reflects the brightness of the tooth on a scale from black to white (5). Shade selection requires the clinician to correlate the optical characteristics of natural dentition with the properties of composite resins or ceramic materials. This task demands knowledge, focused attention, and control of factors such as illumination, environmental conditions, and the choice of shade guides. Consequently, clinicians must rely on adequate training, experience, and appropriate techniques to ensure accurate color matching in both simple and complex rehabilitative procedures (6).

Reproducing natural tooth color poses a significant challenge in clinical practice. Several methods are available for shade determination, with visual shade selection using shade guides—such as the VITA Classical® and the VITA 3D-Master Shade Guide® ((VITA Zahnfabrik, Bad Säckingen, Germany) remaining the most widely used approach (7). The VITA Classical® shade guide is organized according to hue and chroma, with four hue groups

(A—reddish-brown, B—reddish-yellow, C— greyish shades, and D—reddish-gray) and chroma levels ranging from 1 to 4. However, this guide lacks systematic representation of value, a critical parameter for accurate shade selection, and is often described as biased toward yellow hues, providing limited options for high-value shades and insufficient representation of darker shades seen in aging dentition or post-bleaching color changes (8). The VITA 3D-Master Shade System® was developed to overcome these limitations by systematically covering the three-color dimensions. Its 26 shades are divided into five value groups, with chroma and hue variations designated within subgroups. Shade matching begins with identifying the appropriate value group, followed by selecting the chroma level and then the hue (9). Despite its broader chromatic coverage, the VITA Classical® remains the most used guide due to its long-standing presence in the market and widespread adoption by resin manufacturers (6).

In pursuit of objectivity, instrumental methods—including spectrophotometers, colorimeters, and spectroradiometers—have been recommended as adjuncts to visual shade selection. These devices emit controlled light and measure the reflected spectrum to identify color parameters with high precision [9]. Spectrophotometers can detect subtle color differences imperceptible to the human eye, thereby reducing subjectivity and operator-dependent errors. Their advantages include elimination of visual fatigue, standardized illumination, and increased reproducibility; limitations are mainly related to inadequate operator training or improper device calibration (10,11).

Evidence suggests that shade-matching proficiency is influenced by factors such as age, professional experience, and congenital color vision deficiencies. While some studies indicate that clinical experience enhances shade-matching accuracy among dental professionals engaged in restorative procedures, other research reports conflicting findings (12,1). For instance, female participants have been shown to perform better than males in certain shade differentiation tasks, whereas clinical experience was not consistently associated with improved accuracy (13). Conversely, other investigations report that clinical experience is essential for accurate shade selection of natural teeth, prosthetic materials, and restorative substrates (12). Training interventions have also been shown to significantly improve shade-matching performance (14). Although spectrophotometers increase shade-matching accuracy by approximately one-third compared with conventional methods, their routine use in clinical practice remains limited due to high acquisition costs (15).

The demand for esthetic restorations has risen substantially in recent decades. Whereas gold restorations were historically viewed as a symbol of status, contemporary patients increasingly prefer restorations that closely replicate the appearance of natural dentition (16). Achieving this requires careful reproduction of form, translucency, surface texture, and color. As a result, training undergraduate students and practicing clinicians in advanced shade-matching principles has become essential. Moreover, the incorporation of digital dentistry into clinical workflows has proven beneficial by enhancing versatility, efficiency, and precision. It is therefore important to assess whether digital devices genuinely improve clinical outcomes and whether their cost is justified within the context of routine dental practice. This body of research contributes valuable insights to clinical dentistry, supporting more accurate tooth shade selection and promoting best practices in the teaching of esthetic dentistry.

Thus, the objective of this study was to evaluate whether conventional shade selection using the VITA Classical® and VITA 3D-Master Shade System®, performed by undergraduate dental student's at different stages of training, corresponds with the shade values obtained using a digital spectrophotometer. The null hypothesis is that there is no statistically significant difference between the shade selections made using conventional methods (VITA Classical® and VITA 3D-Master®) and those obtained with a digital spectrophotometer, regardless of the student's level of training.

MATERIAL AND METHODS

Study Design

This observational and cross-sectional study was conducted with preclinical students (no clinical experience) and clinical students (0.5 to 1.5 years of clinical experience) enrolled in the undergraduate Dentistry program at a Brazilian university. Clinical-stage students are those who attend the university clinic and perform dental procedures of varying complexity, whereas preclinical students have not yet had contact with patients and do not perform clinical procedures. A total of 80 dental students of both genders were included in this study.

For shade analysis, the VITA Classical® shade guide (Vita Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany), the VITA 3D-Master Shade Guide® (Vita Zahnfabrik H. Rauter GmbH & Co. KG), and the Vita Easyshade Advance 4.0 spectrophotometer (Vita Zahnfabrik H. Rauter GmbH & Co. KG) were used. Shade assessments were performed under ambient light and under a 5500 K color-temperature light

source (Table 1). A total of 80 patients were evaluated (each student assessed one individual). Dental students who participated in the study had previously received theoretical and/or practical training in tooth shade selection during earlier stages of their dental curriculum. However, before beginning shade selection, students received additional training on the use of the VITA Classical and VITA 3D-Master shade guides. Spectrophotometric analysis was performed by a researcher after the student's shade selection and without witnessing the student's use of the visual shade guides.

Table 1 - Experimental procedures.

Clinical Experience (Years) (n=20)	Light	Shade Selection
0	<ul style="list-style-type: none"> • Ambient • Dental Reflector 	<ul style="list-style-type: none"> • Vita Classical (VC) • Vita 3D Master (V3D) • Easyshade (ES)
0.5	<ul style="list-style-type: none"> • Ambient • Dental Reflector 	<ul style="list-style-type: none"> • Vita Classical (VC) • Vita 3D Master (V3D) • Easyshade (ES)
1.0	<ul style="list-style-type: none"> • Ambient • Dental Reflector 	<ul style="list-style-type: none"> • Vita Classical (VC) • Vita 3D Master (V3D) • Easyshade (ES)
1.5	<ul style="list-style-type: none"> • Ambient • Dental Reflector 	<ul style="list-style-type: none"> • Vita Classical (VC) • Vita 3D Master (V3D) • Easyshade (ES)

Ethical Aspects

The study protocol, including the involvement of human subjects (students and patients), was reviewed and approved by the Research Ethics Committee of the Universidade de Uberaba (CAAE 81813024.9.0000.5145). This research was conducted in full accordance with the ethical principles of the Declaration of Helsinki, as revised in 2013. Prior to participation, all subjects—both students and patients—received a detailed explanation of the study's objectives, procedures, and potential risks and benefits. Voluntary informed consent was obtained from all participants, who retained the right to withdraw from the study at any

point. Written informed consent was documented via the signed Informed Consent Form (ICF).

Inclusion and Exclusion Criteria – Dental Students

Students enrolled in the preclinical stage (no experience) and in the clinical stages corresponding to 0.5, 1.0, and 1.5 years of clinical experience were eligible for inclusion. Student selection was random until the target number of participants (20 per experience level) was reached. As an exclusion criterion, color-vision deficiency screening was performed using the Ishihara Test, consisting of 24 plates displayed on an iPad (Apple, California, USA) through the PseudoChromatic ColorTest application (Cassiopeia Information Technologies, USA). For each plate displayed, participants were asked to identify the number contained within the circle. Responses were recorded on the Ishihara Test answer sheet. Participants who misidentified four or more of the 24 plates were excluded from the study (17).

Inclusion and Exclusion Criteria – Patients

Pacientes selected for this study were those already undergoing treatment at the Polyclinic Getúlio Vargas – UNIUBE, of both genders, and aged between 18 and 40 years. Eligible patients were required to present at least one sound maxillary central incisor (right or left), free of composite restorations, white-spot lesions, or any enamel defects. Patients not meeting the inclusion criteria or those who declined to sign the informed consent form were excluded.

Shade Analysis

Patients selected for shade evaluation were already receiving routine care at the university clinic and met the age and health criteria described above. Prior to shade evaluation, each patient was positioned at a 45° angle relative to the floor, and a prophylaxis of the entire dental arch was performed using pumice and water with a Robinson brush at low speed.

The tooth selected for evaluation was the maxillary right or left central incisor. Shade assessments were always conducted in the same operatory, located in front of a window.

A black intraoral photographic background was placed in the patient's mouth, and the participating student performed tooth shade selection using the VITA Classical shade guide (Vita Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany) under ambient light, followed by evaluation under a specific dental light source (LK – KaVo, 20,000 lx, 5500 K,

45° incidence angle, at 90 cm distance), according to the specifications of the Commission Internationale d'Eclairage (CIE) (18). Shade selection followed the manufacturer's instructions for the visual shade guides. Each patient was evaluated only once, during their routine appointment. In total, 80 patients were evaluated, and the selected shade values were recorded for later analysis.

Next, a researcher—who did not observe the conventional shade selection—performed digital shade measurements of the same tooth using the Vita Easyshade Advance 4.0 spectrophotometer, following manufacturer instructions. A polyurethane infection-control sheath supplied by the manufacturer was stretched uniformly over the handpiece probe. Calibration was performed by placing the probe vertically in contact with the calibration block. The handpiece tip was then positioned perpendicularly against the middle third of the central incisor. The activation button was pressed until an audible signal confirmed the measurement. The result was then displayed, including the corresponding VITA Classical shade. This procedure was repeated three times to assess measurement reproducibility. All three measurements were recorded. After recalibration, the same procedure was repeated to obtain the corresponding VITA 3D-Master shade values using the spectrophotometer.

Statistical Analysis

Data from the conventional shade assessments and spectrophotometric measurements were compiled and analyzed statistically. Observed agreement, chance-expected agreement, weighted observed agreement, and the intra-examiner weighted Kappa coefficient (κ), calculated using the quadratic equation, were determined for each evaluated group.

A two-way analysis of variance (ANOVA) was performed, followed by Tukey's post-hoc test, to identify which student groups demonstrated the highest agreement with the spectrophotometer and to determine whether differences existed between shade selections performed under ambient light and under the dental light source. The significance level was set at 5%.

RESULTS

The agreement between visual and spectrophotometric shade selection, expressed as weighted quadratic Kappa coefficients, varied according to the light condition, the shade guide system, and the students level of clinical experience (Table 2).

Table 2 - Agreement between color determination methods (weighted quadratic Kappa \pm standard error) according to clinical experience and light condition (VC= Vita Classical, Es= EasyShade; V3D= Vita 3D Master).

Clinical Experience (years) (n=20)	Ambient Light		Dental Light	
	VC x ES	V3D x ES	VC x ES	V3D x ES
0	0.22(0.09)Aa	0.29(0.08)Aa	0.13(0.08)Ba	0.04(0.06)Ca
0.5	0.28(0.10)Aa	0.28(0.08)Aa	0.20(0.09)Ab	0.13(0.08)Bb
1	0.27(0.08)Aa	0.27(0.07)Aa	0.21(0.06)Ab	0.24(0.09)Ac
1.5	0.40(0.08)Ab	0.42(0.07)Ab	0.25(0.07)Bb	0.21(0.09)Bc

Uppercase letters compare the rows, and lowercase letters compare the values within the same column. Different letters indicate statistically significant differences ($p < 0.05$).

Under ambient light, both shade guide systems (Vita Classical and Vita 3D-Master) showed a progressive increase in agreement with the spectrophotometer (Vita Easyshade) as clinical experience increased. For the Vita Classical guide, the mean Kappa value rose from 0.22 ± 0.09 among students without clinical experience to 0.40 ± 0.08 after 1.5 years of experience. Similarly, for the Vita 3D-Master system, the Kappa value increased from 0.29 ± 0.08 to 0.42 ± 0.07 over the same period.

According to the Landis and Koch classification (19), Kappa values are interpreted as follows: < 0.00 = poor agreement; $0.00-0.20$ = slight; $0.21-0.40$ = fair; $0.41-0.60$ = moderate; $0.61-0.80$ = substantial; and $0.81-1.00$ = almost perfect agreement. Based on this scale, the present findings indicate that shade matching performed by students without clinical experience exhibited only slight agreement with the spectrophotometer, whereas students with longer experience reached the threshold of moderate agreement, particularly under ambient lighting conditions.

Under dental light, the agreement values were generally lower than those obtained under ambient light, especially for the Vita Classical system. Nonetheless, a gradual improvement in Kappa values was still observed with increasing clinical experience. For the Vita Classical guide, Kappa increased from 0.13 ± 0.08 (no experience) to 0.25 ± 0.07 (1.5 years), whereas for the Vita 3D-Master system, values improved from -0.04 ± 0.06 to $0.21 \pm$

0.09. These data suggest that, although controlled dental light provides a consistent illumination source, it may accentuate small perceptual color differences, thus affecting visual matching accuracy among inexperienced students.

The statistical comparison using two-way analysis of variance (ANOVA) confirmed that clinical experience had a significant effect on the level of agreement between visual and spectrophotometric methods ($p < 0.05$). Under ambient light, both shade guides demonstrated significantly higher Kappa values in students with 1.5 years of clinical experience compared with those without any experience ($p < 0.05$). Under dental light, this effect was less pronounced; significant differences were found only for the Vita 3D-Master system, where students with one year of clinical practice exhibited better agreement with the spectrophotometric reference ($p < 0.05$).

These results demonstrate a clear influence of clinical experience on the accuracy and reproducibility of visual color selection. Students with greater clinical exposure exhibited improved ability to perceive and interpret subtle chromatic and value differences among shade tabs, resulting in higher Kappa coefficients. The overall findings highlight that visual shade matching skills are enhanced not only by experience but also by environmental lighting conditions, with ambient light promoting more consistent color assessments. The Vita 3D-Master system appeared to benefit most from clinical training, suggesting that its structured organization of hue, chroma, and value facilitates learning and improves visual color-matching performance over time.

DISCUSSION

The reproducibility and accuracy of visual shade selection represent a central challenge in esthetic dentistry. The present study used the weighted quadratic Kappa coefficient to quantify the degree of agreement between visual methods (Vita Classical and Vita 3D-Master) and the instrumental method (Vita EasyShade), revealing that both observer experience and lighting conditions are determining variables. The findings in this work demonstrate that visual shade selection is a multifactorial skill dependent on cognitive and perceptual aspects as well as technical and environmental characteristics. Regarding the influence of clinical experience on the accuracy of shade selection, the results showed that agreement between visual selection and spectrophotometry progressively increased as students gained more clinical experience. Thus, the null hypothesis that there is no statistically

significant difference between the shade selections made using conventional methods and those obtained with a digital spectrophotometer, regardless of the students' level of training was rejected.

The increase in clinical experience is generally measured by the length of exposure and the number of procedures performed (20). Thus, the group of novice/less experienced students showed low agreement because they rely more on short-term memory and are highly susceptible to environmental conditions (lighting). The intermediate student group demonstrated improved agreement, as they begin to develop a mental library of shades and values (hue, chroma, value) and gain familiarity with shade guides (VITA Classical and VITA 3D-Master Shade System). Finally, the advanced/experienced student group (1.5 years of experience) showed high agreement, with a more refined ability to differentiate color. In other words, they master the observational technique (timing, distance, posture, lighting conditions) and can identify value (brightness/luminosity) — the most critical parameter in shade selection—with greater visual precision. These findings are consistent with recent studies highlighting that the ability to differentiate color improves significantly with continuous clinical training (21,20,22,23).

The perception of subtle differences in value, hue, and chroma is understood to depend on cognitive-perceptual development, which occurs through repeated exposure to clinical situations. Evidence also indicates that dental students show measurable improvements in shade-selection accuracy after participating in structured learning modules that combine theoretical content, supervised practice, and standardization exercises. Furthermore, training that provides immediate feedback—allowing students to compare their visually selected shade with the digital reading of a spectrophotometer—has been shown to accelerate gains in accuracy (21,24).

For students without clinical experience, agreement under ambient light was higher than under dental light for both guides. The progressive increase in agreement observed in the present study, particularly after 1.5 years of experience, supports the notion that day-to-day clinical practice is the most decisive factor in developing chromatic judgment skills, surpassing even mere familiarity with shade guides. Additional research has emphasized that professionals with longer clinical experience demonstrate greater consistency in their visual selections, regardless of the shade system employed (25). It should be noted that the results of the present investigation were obtained from students at different clinical stages during

undergraduate training, which limits direct comparison with fully qualified clinicians and/or specialists.

When comparing the VITA Classical and VITA 3D-Master Shade System, the results showed that, under dental lighting, the VITA Classical demonstrated superior performance as clinical experience increased up to 0.5 years of experience, when compared with the VITA 3D Master System. The agreement of students with 1.5 years of experience was higher for both guides when the analysis was performed under ambient light.

A past study noted that the VITA 3D-Master Shade System enables a more systematic shade-matching process because it is based on perceptual parameters organized into a structure of value, chroma, and hue (26). This structure facilitates students' gradual understanding of the color spectrum and reduces common errors among experienced clinicians. It has also been emphasized that starting with value—the most perceptible parameter to the human eye—makes the system more intuitive and supports learning (27).

Recent comparative studies have further shown that the VITA Classical system presents limitations due to its irregular color distribution and the absence of a logical progression between shade groups, which may explain why less experienced students performed more poorly with this system, particularly under dental lighting (28,29).

The superior performance of the VITA 3D-Master Shade System was found for the most experienced students under ambient light. It has been suggested that the VITA 3D-Master Shade System supports continuous learning because it more closely reflects the actual color dimensions observed in natural teeth (30).

Regarding the effect of lighting conditions, the significant differences observed between ambient and dental lighting reinforce recent conclusions emphasizing the decisive influence of illumination characteristics on shade-selection performance in dentistry. Studies have demonstrated that ideal lighting for shade matching should have a color temperature between 5,500 K and 6,500 K and a color rendering index (CRI) above 90 (31,32). The present study adopted a specific dental light source with a temperature of 5,500 K. However, clinical environments often fail to meet these parameters, particularly when operatory lights are used, as they may cause distortions due to excessive direct brightness or suboptimal color temperature.

This helps explain why, in the present study, ambient lighting promoted greater agreement with the spectrophotometer, especially among novice students. It has been argued that dental lighting amplifies value differences, making perception more challenging for inexperienced evaluators (33). Additionally, recent studies incorporating detailed spectral analyses of clinical light sources have shown that even small variations in spectral composition directly influence how enamel and dentin reflect light, confirming that minor changes in illumination can alter color judgment (34).

The findings of the present study therefore reinforce current recommendations in the literature that visual shade selection should preferably be performed under natural light or with calibrated auxiliary devices, such as D65 portable lamps, particularly during student training (36).

Regarding the reliability of digital methods and their integration into clinical practice, digital devices—represented in this study by the VITA EasyShade spectrophotometer—continue to be widely recognized in the current literature as the gold standard for the objective determination of dental color. Recent studies have demonstrated that digital devices exhibit high reproducibility and lower inter-examiner variability (35,36). Nonetheless, these studies emphasize the importance of proper device calibration and professional training.

However, it has been cautioned that although digital methods reduce the influence of subjective factors, they do not fully replace final clinical judgment, as they are unable to capture essential characteristics such as opalescence, translucency, and surface texture (37,38).

The superiority of ambient light over the dental operating light in shade selection is based on the greater stability of its emission spectrum and on the physiology of human visual perception. Conventional dental operating lights often present a reduced Color Rendering Index (CRI) and a color temperature shifted toward the yellow spectrum, which compromises the accurate perception of hue and chroma. In addition, the high luminous intensity of the operating light may induce early saturation of retinal cone cells, increasing the contrast sensitivity threshold and impairing the discrimination of subtle variations in value and translucency. These spectral discrepancies promote the occurrence of metamerism, an optical phenomenon in which objects with different reflectance curves appear to match chromatically under a specific light source but exhibit significant discrepancies when evaluated under other illumination conditions, particularly natural daylight (39).

This study has certain limitations. Ideally, all participating students would have evaluated the same patient to ensure uniformity of clinical exposure and assessment conditions. However, logistical and organizational constraints precluded the implementation of this approach.

Based on this, the most recent literature recommends that teaching protocols combine both visual and digital methods, using the spectrophotometer as a calibration tool for training. The present study supports this trend by demonstrating that students' visual agreement increases when it is systematically compared with spectrophotometric readings. Structured training in visual perception, the use of standardized shade guides and auxiliary devices, as well as simulated clinical scenarios, could enhance students' accuracy in color assessment. Future studies should compare student's performance with that of practicing clinicians to better understand the influence of professional experience on shade-matching accuracy.

CONCLUSION

Clinical experience substantially improves the accuracy of visual shade matching, reinforcing the importance of progressive exposure to real clinical situations in developing perceptual and technical competencies. Ambient light proved to be more reliable than operatory lighting, suggesting that natural or standardized illumination should be prioritized during both training and clinical procedures. Among the conventional shade guides evaluated, the VITA Classical system demonstrated greater consistency across different levels of student experience, indicating its continued relevance as a teaching and clinical tool.

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4 CONCLUSÃO

Os resultados deste estudo mostraram que a acurácia na seleção de cor está associada à experiência clínica. A iluminação ambiente é mais adequada que o refletor odontológico para essa avaliação. O sistema VITA Classical demonstrou maior reprodutibilidade entre os avaliadores, consolidando seu uso na formação e na prática odontológica.

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APÊNDICE A – FIGURAS ELABORADAS PELO AUTOR

Figura 1 - Seleção de cor usando a Escala VITA Classical/ Luz ambiente.



Fonte: Arquivo pessoal, 2026.

Figura 2 - Seleção de cor usando a Escala VITA Classical/ Refletor odontológico.



Fonte: Arquivo pessoal, 2026.

Figura 3 - Seleção de cor usando a Escala VITA 3D-Master/ Luz ambiente.



Fonte: Arquivo pessoal, 2026.

Figura 4 - Seleção de cor usando a Escala VITA 3D-Master/ Refletor odontológico.



Fonte: Arquivo pessoal, 2026.

Figura 5 - Seleção de cor usando o Espectrofotômetro/ Luz ambiente.



Fonte: Arquivo pessoal, 2026.

Figura 6 - Seleção de cor usando o Espectrofotômetro/ Refletor odontológico.



Fonte: Arquivo pessoal, 2026.

ANEXO A- APROVAÇÃO DO COMITÊ DE ÉTICA

DETALHAR PROJETO DE PESQUISA																							
- DADOS DA VERSÃO DO PROJETO DE PESQUISA																							
<p> Título da Pesquisa: INFLUÊNCIA DA TÉCNICA E DO NÍVEL DE CONHECIMENTO NA CORRESPONDÊNCIA DA ESCOLHA DE CORES EM ODONTOLOGIA Pesquisador Responsável: Vinicius Rangel Geraldo Martins Área Temática: Versão: 1 CAAE: 81813024.9.0000.5145 Submetido em: 28/06/2024 Instituição Proponente: Sociedade Educacional Uberabense Situação da Versão do Projeto: Aprovado Localização atual da Versão do Projeto: Pesquisador Responsável Patrocinador Principal: Financiamento Próprio </p> <div style="text-align: right; margin-top: 10px;">  </div> <p style="text-align: right; margin-top: 10px;"> Comprovante de Recepção:  PB_COMPROVANTE_RECEPCAO_2368456 </p>																							
+ DOCUMENTOS DO PROJETO DE PESQUISA																							
- LISTA DE APRECIÇÕES DO PROJETO																							
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