Instrumental Colorimetric Evaluation of Combined Enamel and Dentin Composite Resins Compared to the Vita Classic Shade Guide

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Abstract: Accurate color determination in dental restorations is crucial for achieving aesthetically pleasing and functional results. Traditionally, color selection has been performed using visual methods, which are subject to observer variability and factors such as lighting and experience. However, the use of instrumental technologies like spectrophotometry has allowed for greater objectivity and reproducibility in color measurement. This study aims to evaluate the accuracy of color determination in composite resin restorations using spectrophotometry, comparing the results obtained with the Vita Classic shade guide.

A total of 120 samples were prepared using 4 types of composite resins and 3 enamel/dentin combinations (A2, A3, and A3.5), with 0.7 mm thickness for enamel and 1.3 mm for dentin, achieving a final thickness of 2 mm. Color measurements were taken with a Vita™ Easyshade® spectrophotometer, and the results were expressed in terms of ΔE using the CIE Lab* formula. Normality (Shapiro-Wilk) and homoscedasticity (Levene) tests were applied, and one-way ANOVA was used to assess differences between resin brands and shades.

The results showed that, although no statistically significant differences were found in the A2 and A3 shades between brands, the A3.5 shade exhibited significant variations, with Filtek Z350 XT® 3M Espe Solventum being the resin that showed color values closest to the ideal.

Keywords: Esthetics, Dentistry, Color, Spectrophotometry, Biomimetic materials, rehabilitation.

INTRODUCTION

In restorative dentistry, accurate shade selection and reproduction are critical to achieve functional and aesthetic expectations. Traditionally, color determination has been carried out using visual methods, which, although widely used, present high observer variability due to factors such as lighting, visual fatigue and operator experience.

The development of technologies such as spectrophotometry has allowed greater objectivity and reproducibility in color determination. This instrumental method evaluates colorimetric characteristics based on the CIE Lab scale, offering more precise results compared to visual methods. However, its implementation in the clinic has several challenges, since factors such as the composition of the resins and the calibration of the device can influence the results obtained.

The main objective of this study is to evaluate the correlation between the colorimetric characteristics obtained by spectrophotometry and those provided by the Vita Classic® scale in composite resins from different brands, using the combination of enamel and dentin shades A2, A3 and A3.5. This study protocol complies with the relevant ethical guidelines and is approved by the institutional ethics and biosecurity Committee.

MATERIALS AND METHOD

Descriptive *in vitro* study without biological samples, based on the preparation and observation of composite resin samples from different four brands were used in shades to evaluate correlation between the colorimetric characteristics in mixed composite restorations that simulate enamel-dentin of different brands, through reading with a spectrophotometer in an *in vitro* study.

An analytical study was performed using four commercial brands of composite resins (Filtek Z350 XT® 3M Espe Solventum™, Weisswiss® Swisstec™, Forma® Ultradent™ and Spectra® Dentsply Sirona™) in shades A2, A3 and A3.5, coded according to the Vita Classic® scale.

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The study universe corresponds to enamel and dentin composite resins, for direct restoration technique. Four composite resins from different manufacturers were selected in their A2, A3 and A3.5 shade variants, based on the Vita Classic shade nomenclature.

The sample size consisted of 120 samples, which were prepared under the following conditions: 4 brands of resins, 3 enamel/dentin combinations (A2- A3 and A3.5) in a final thickness of 2 mm (with thicknesses of 0.7 mm for enamel and 1.3 mm for dentin), and 10 discs for each combination.

Sample preparation: resin discs with a diameter of 10 mm and thicknesses of 0.7 mm for enamel and 1.3 mm for dentin were made. The samples were made with 3D printed plastic matrices, one 0.7 mm thick and the other 1.3 mm thick, and were verified with a metal gauge (Germany Stainless Inox). Polymerization was performed with a Woodpecker® LED lamp at 3200 mW/cm² for the time specified by the manufacturer. Sample preparation was performed by a single operator, respecting safety barriers to avoid contamination.

Color measurement: the dentin-simulating resin disc was placed in the positioner, glycerin was applied to fix the enamel-simulating disc, ensuring that there was no displacement. The dark box was closed before positioning the spectrophotometer to ensure reproducible measurements.

A Vita Easyshade® spectrophotometer was used in "Medium Color Determination" mode. Each sample was measured five times, and the average CIE L*, a*, and b* values were recorded in a Microsoft Excel spreadsheet. Color differences (Delta E) were calculated using the equation $\Delta E^* = \{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\}^{1/2}$.

Statistical analysis: normality (Shapiro-Wilk) and homoscedasticity (Levene) tests were performed to verify parametric assumptions. One-way ANOVA analysis was used to determine statistically significant differences, considering a significance level of $p < 0.05$.

RESULTS

The analysis of the results was carried out by evaluating the correlation between the colorimetric characteristics measured with spectrophotometry and the values of the Vita Classic scale in composite resins of different brands.

Descriptive results: the average Delta E values and their standard deviations for each shade and brand are presented in Table **1**.

Normality and homoscedasticity analysis: normality tests (Shapiro-Wilk) and homoscedasticity (Levene) were performed to ensure compliance with parametric assumptions before applying ANOVA.

Normality tests: results of the Shapiro-Wilk test for shades A2 and A3 showed p values > 0.05 in all brands, indicating that the data follow a normal

Table 1: Average Delta E Values and Standard Deviations by Shade and Brand

Brand	Shade	Average	Standard Deviation
Filtek 350 XT	A2	25,53277992	4,19078597
	A3	24,7743171	0,54567892
	A3,5	16,05375817	123326218
Weisswiss	A2	14,11645552	0,38775544
	A3	17,18907849	1,8751602
	A3,5	5,293759279	2,40159132
Forma	A2	14,2984965	1,63890124
	A3	15,30318931	2,96660518
	A3,5	2,573596789	0,38177147
Spectra	A2	14,01841811	0,74979461
	A3	18,05398607	0,99107698
	A3,5	17,54323679	1,13404305

distribution. For shade A3.5, all brands showed a normal distribution, except for Filtek Z350 XT® ($p < 0.05$). This small deviation is considered compensated in the ANOVA analysis due to the robustness of the statistical test.

Homoscedasticity test: Levene test for homogeneity of variances yielded $p > 0.05$, confirming that the variances between brands are homogeneous and parametric tests can be used.

Analysis of variance (ANOVA): ANOVA analysis was applied to evaluate significant differences between the brands in each of the shades.

Shade A2: one-way ANOVA showed that there are no statistically significant differences ($p > 0.05$) between the brands for shade A2. This indicates that the Delta E values are consistent between the analyzed composite resins.

Shade A3: ANOVA results for shade A3 also indicated the absence of statistically significant differences ($p > 0.05$) between the brands. This suggests that all the analyzed resins have a similar colorimetric behavior in this shade.

Shade A3.5: unlike the previous shades, the ANOVA analysis for shade A3.5 showed statistically significant differences ($p < 0.05$) between the brands. This finding indicates that there are notable variations in the colorimetric characteristics of the resins for this shade. In particular, Filtek Z350 XT® showed the closest to ideal Delta E values, while other brands showed greater dispersion.

Graphical interpretation: Results are illustrated in Figure **1**, which shows the dispersion of Delta E values for each brand and shade, highlighting significant differences in shade A3.5.

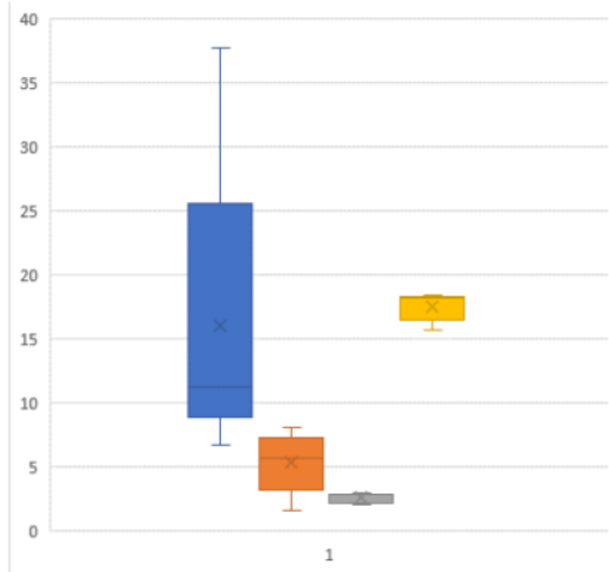

Figure 1: Scatter plot of Delta E values by brand and shade. A3.5 distribution chart.

Comparison between visual and instrumental methods: Delta E and clinical perception: A complementary analysis was added to compare the values obtained by spectrophotometry with those estimated using the Vita Classic scale. Delta E values greater than 3.3 are considered clinically perceptible. In this study, shades A2 and A3 presented consistent values between brands, while in shade A3.5 the differences reached perceptible values in some brands, reflecting a greater variability in this shade. The interpretation of these values is in Table **2**.

DISCUSSION

The analysis of the results highlights statistically significant differences for the A3.5 shade, while the A2 and A3 shades did not present notable discrepancies between brands, which partially agrees with previous studies. [1-5] However, we must take into account that it was used based on the values of Imbery (2013), and

Table 2: ΔE Values and their Interpretation

ΔE Values	Interpretation
ΔE less than 1	The color difference will not be perceived by the human eye.
ΔE between 1 and 2	The color difference will be perceived by an experienced observer.
ΔE between 2 and 3	Obvious difference between reference color and obtained color, but it is acceptable.
ΔE between 3 and 4	Obvious difference between reference color and obtained color, but it does not harm the work done.
ΔE between 4 and 5	Obvious difference between reference color and obtained color, at the limit of acceptance.
ΔE higher than 5	Obvious difference between reference color and obtained color, unacceptable.

VITA™ does not provide information about these values. [6-10]

In particular, Filtek Z350 XT® showed more consistent and closer to ideal Delta E values, possibly due to its formulation that includes an optimized resin matrix and uniform filler particles, characteristics that influence the optical properties of the material [11-15]. It should be noted that for this particular resin, Filtek Z350 XT® body or universal was used, since there is no easy access to resins that imitate dentin and enamel [16-20].

The influence of factors such as thickness, degree of polymerization and composition of composite resins has been pointed out in previous studies as critical variables for color determination [21-24]. Although in this study the samples were not subjected to polishing techniques to maintain standardization, various investigations [25-28] have shown that surface irregularities can alter color perception, especially in subjective methods such as visual assessment [29-31].

It is important to mention that spectrophotometers, such as the Vita Easyshade®, provide a more objective and reproducible measurement compared to the Vita Classic® scale, which depends on the operator's perception. However, the clinical environment, calibration of the device and light characteristics can influence the results. For example, discrepancies between instrumental readings and expected values according to the CIE Lab scale may be due to factors such as lack of standardization in measurement conditions [32-34].

At the clinical level, shade selection for layered restorative techniques remains a challenge, especially when using universal resins rather than those specifically designed to simulate enamel and dentin. These limitations underscore the need for more precisely coded materials compatible with instrumental methods. Future studies could explore the influence of filler type and other additives on color stability and reproducibility [35, 36].

The analysis indicated that shade A3.5 presented statistically significant differences, suggesting that resin properties such as matrix and filler composition influence color perception. Shades A2 and A3 showed consistency between brands, aligning with previous studies highlighting the utility of the spectrophotometer as an objective tool for shade selection [37, 38].

Despite the advantages of spectrophotometry, its accuracy can be affected by device calibration and clinical environment. Furthermore, factors such as thickness and degree of polishing can alter results, underscoring the need to standardize procedures.

CONCLUSIONS

The mixed A2 and A3 resin groups that simulate enamel and dentin do not show correlation of colorimetric characteristics with respect to the measurement with a spectrophotometer. On the other hand, the mixed A3.5 resin group showed results where there is a correlation of colorimetric characteristics coded according to the visual scale by the manufacturer with the instrumental method of the VITA™ Easyshade V® spectrophotometer.

The A3.5 resin complies with the colorimetric characteristics under the CieLab system, but not the A2 and A3 colors for the different brands.

For both A2 and A3 colors there is no correlation between *in vitro* measurements using a spectrophotometer.

LIMITATIONS

One of the limitations of the study was that, despite the large number of resins and their equivalent colors studied, the number of brands was very small. Some of the resins exposed did not have their equivalent in color and tone for enamel and dentin, since a universal composite resin was used.

CONFLICT OF INTEREST

The equipment, measurement and evaluation were managed as loans and/or donations. The research group had no contact with representatives of the brands. The authors declare that there are no conflicts of interest in the conduct of this study.

AUTHOR CONTRIBUTIONS

Author 1 Jaime Sarmiento-Cornejo: Contributed to conception, design, data interpretation, drafted and critically revised the manuscript.

Author 2 Raimundo Sarmiento-Osterreich: Contributed to conception, design, data interpretation, drafted and critically revised the manuscript.

Author 3 Leslie Hidalgo-Roldán: Contributed to data interpretation, drafted and critically revised the manuscript.

Author 4: Nicolás Antonio-Benavente: Contributed to design, data acquisition and interpretation, performed all statistical analyses.

Author 5 Bárbara Godoy-Álvarez: Contributed to design, data acquisition and interpretation, performed all statistical analyses.

Author 6: Pablo Villalobos-Castro: Contributed to design, data acquisition and interpretation, performed all statistical analyses.

All authors gave their final approval and agree to be accountable for all aspects of the work.

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REFERENCES

[1] Chu SJ. Precision shade technology: contemporary strategies in shade selection. Pract Proced Aesthet Dent. 2002; 14(1): 79-83; quiz 84.

[2] Villarroel M, Fahl N, De Sousa AM, De Oliveira OB Jr. Direct esthetic restorations based on translucency and opacity of composite resins: Composite resins' esthetic restorations. J Esthet Restor Dent [Internet]. 2011; 23(2): 73-87. https://doi.org/10.1111/j.1708-8240.2010.00392.x

[3] Kaizer M da R, Diesel PG, Mallmann A, Jacques LB. Ageing of silorane-based and methacrylate-based composite resins: effects on translucency. J Dent [Internet]. 2012; 40 Suppl 1: e64-71. https://doi.org/10.1016/j.jdent.2012.04.014

[4] Ginzburg M, Gilboa I. Tooth color matching systems and communication with dental laboratory in indirect restorations: 2011 update. Refuat Hapeh Vehashinayim. 2012; 29(1): 28-34, 64.

[5] Pascual A, Camps I. Aesthetic dentistry: Chromatic appreciation in the clinic and the laboratory. Med Oral Patol Oral Cir Bucal. 2016; (11): 363-8.

[6] Giel C, Weyhrauch M, Wentaschek S, Scheller H, Lehmann K. Dental color matching: A comparison between visual and instrumental methods. Dental Materials Journal. 2016; 35(1): 63-9. https://doi.org/10.4012/dmj.2015-006

[7] Ritter AV. COMMENTARY. Comparison of various resin composite shades and layering technique with a shade guide. J Esthet Restor Dent [Internet]. 2010; 22(2): 125-6. https://doi.org/10.1111/j.1708-8240.2010.00323.x

[8] Igiel C, Weyhrauch M, Wentaschek S, Scheller H, Lehmann KM. Dental color matching: A comparison between visual and instrumental methods. Dent Mater J [Internet]. 2016; 35(1): 63-9. https://doi.org/10.4012/dmj.2015-006

[9] da Costa J, Fox P, Ferracane J. Comparison of various resin composite shades and layering technique with a shade guide. J Esthet Restor Dent [Internet]. 2010; 22(2): 114-24. https://doi.org/10.1111/j.1708-8240.2010.00322.x

[10] Sarmiento J, Morales J, Hidalgo L, Leiva I. Evaluación instrumental colorimétrica de resinas compuestas que imitan dentina en comparación a escala vita clásica. Appli Sci Dent [Internet]. 2020 [cited 2024 Dec 12]; 1(1). https://doi.org/10.22370/asd.2020.1.1.2113

[11] Elamin HO, Abubakr NH, Ibrahim YE. Identifying the tooth shade in group of patients using Vita Easyshade. Eur J Dent [Internet]. 2015; 9(2): 213-7. https://doi.org/10.4103/1305-7456.156828

[12] Imbery TA, Geissberger M, Hakim F, Al-Anezi S, Uram-Tuculescu S, Gottlieb R, et al. Evaluation of four dental clinical spectrophotometers relative to human shade observation. J Am Dent Assoc [Internet]. 2013; 144(10): 1183-6. https://doi.org/10.14219/jada.archive.2013.0041

[13] Paravina RD, Kimura M, Powers JM. Color compatibility of resin composites of identical shade designation. Quintessence Int. 2006; 37(9): 713-9.

[14] Park S-K, Lee Y-K. Shade distribution of commercial resin composites and color difference with shade guide tabs. Am J Dent. 2007; 20(5): 335-9.

[15] Brewer JD, Wee A, Seghi R. Advances in color matching. Dent Clin North Am [Internet]. 2004; 48(2): v, 341-58. https://doi.org/10.1016/j.cden.2004.01.004

[16] Lu H, Roeder LB, Powers JM. Effect of polishing systems on the surface roughness of microhybrid composites. J Esthet Restor Dent [Internet]. 2003; 15(5): 297-303; discussion 304. https://doi.org/10.1111/j.1708-8240.2003.tb00300.x

[17] Azzopardi N, Moharamzadeh K, Wood DJ, Martin N, van Noort R. Effect of resin matrix composition on the translucency of experimental dental composite resins. Dent Mater [Internet]. 2009; 25(12): 1564-8. https://doi.org/10.1016/j.dental.2009.07.011

[18] Limas MRS, Trujillo CA, Huertas DAM, Rodríguez KLM. Opacidad y translucidez de diferentes resinas compuestas de acuerdo a su tamaño de partícula y su aplicación clínica. Acta Odontol Colomb [Internet]. 2012 [cited 2024 Dec 12]; 2(1): 101-17.

[19] Darabi F, Radafshar G, Tavangar M, Davaloo R, Khosravian A, Mirfarhadi N. Translucency and masking ability of various composite resins at different thicknesses. J Dent (Shiraz). 2014; 15(3): 117-22.

[20] Pornasrollah A, Mosavi SA, Khandero H, Zarandi A. Comparison of color match to Noritake and Vitapan classical shade guides of three porcelain systems. Annals of Applied Bio-Sciences [Internet]. 2016 [cited 2024 Dec 12]; 3. Available from: https: //www.semanticscholar.org/paper/23f72d946fc4f0b7f3337dd9e3fd3813cebca56d

[21] Kim-Pusateri S, Brewer JD, Davis EL, Wee AG. Reliability and accuracy of four dental shade-matching devices. J Prosthet Dent [Internet]. 2009; 101(3): 193-9. https://doi.org/10.1016/S0022-3913(09)60028-7

[22] King KA, deRijk WG. Variations of L*a*b* values among Vitapan Classical shade guides. J Prosthodont [Internet]. 2007; 16(5): 352-6. https://doi.org/10.1111/j.1532-849X.2007.00207.x

[23] Todorović A, Todorović A, Gostović AS, Lazić V, Milicić B, Djurisić S. Reliability of conventional shade guides in teeth color determination. Vojnosanit Pregl [Internet]. 2013; 70(10): 929-34. https://doi.org/10.2298/VSP110513019T

[24] Kim J-G, Yu B, Lee Y-K. Correlations between color differences based on three color-difference formulas using dental shade guide tabs. J Prosthodont [Internet]. 2009;

18(2): 135-40.
https://doi.org/10.1111/j.1532-849X.2008.00393.x

[25] Lee Y-K. Influence of filler on the difference between the transmitted and reflected colors of experimental resin composites. Dent Mater [Internet]. 2008; 24(9): 1243-7.
https://doi.org/10.1016/j.dental.2008.01.014

[26] Yu B, Ahn J-S, Lim JI, Lee Y-K. Influence of TiO2 nanoparticles on the optical properties of resin composites. Dent Mater [Internet]. 2009; 25(9): 1142-7.
https://doi.org/10.1016/j.dental.2009.03.012

[27] Lee Y-K, Yu B, Lee S-H, Cho M-S, Lee C-Y, Lim H-N. Shade compatibility of esthetic restorative materials--A review. Dent Mater [Internet]. 2010; 26(12): 1119-26.
https://doi.org/10.1016/j.dental.2010.08.004

[28] Lee Y-K, Lu H, Powers JM. Influence of fluorescent and opalescent properties of resin composites on the masking effect. J Biomed Mater Res B Appl Biomater [Internet]. 2006; 76(1): 26-32.
https://doi.org/10.1002/jbm.b.30278

[29] Yu B, Lee Y-K. Comparison of stabilities in translucency, fluorescence and opalescence of direct and indirect composite resins. Eur J Esthet Dent. 2013 Summer; 8(2): 214-25.

[30] Lee Y-K, Yu B, Lee S-H, Cho M-S, Lee C-Y, Lim H-N. Variation in instrument-based color coordinates of esthetic restorative materials by measurement method-A review. Dent Mater [Internet]. 2010; 26(11): 1098-105.
https://doi.org/10.1016/j.dental.2010.07.010

[31] Yuan K, Sun X, Wang F, Wang H, Chen J-H. In vitro and in vivo evaluations of three computer-aided shade matching instruments. Oper Dent [Internet]. 2012; 37(3): 219-27.
https://doi.org/10.2341/11-230-C

[32] Alghazali N, Burnside G, Moallem M, Smith P, Preston A, Jarad FD. Assessment of perceptibility and acceptability of color difference of denture teeth. J Dent [Internet]. 2012; 40 Suppl 1: e10-7.
https://doi.org/10.1016/j.jdent.2012.04.023

[33] Lee Y-K, Lim B-S, Kim C-W. Difference in the colour and colour change of dental resin composites by the background. J Oral Rehabil [Internet]. 2005; 32(3): 227-33.
https://doi.org/10.1111/j.1365-2842.2004.01402.x

[34] Dozić A, Kleverlaan CJ, El-Zohairy A, Feilzer AJ, Khashayar G. Performance of five commercially available tooth color-measuring devices. J Prosthodont [Internet]. 2007; 16(2): 93-100.
https://doi.org/10.1111/j.1532-849X.2007.00163.x

[35] Harnirattisai C, Kuphasuk W, Ruengrungsom C, Naorungroj S, Sattabanasuk V. "Enamel layering" using double-layered enamel-shade resin composites: The strategy to simulate the optical characteristics of human enamel. J Esthet Restor Dent [Internet]. 2023; 35(6): 904-16.
https://doi.org/10.1111/jerd.13072

[36] Ismail EH. Color interaction between resin composite layers: An overview. J Esthet Restor Dent [Internet]. 2021; 33(8): 1105-17.
https://doi.org/10.1111/jerd.12806

[37] Ismail EH, Paravina RD. Color adjustment potential of resin composites: Optical illusion or physical reality, a comprehensive overview. J Esthet Restor Dent [Internet]. 2022; 34(1): 42-54.
https://doi.org/10.1111/jerd.12843

[38] Trifkovic B, Powers JM, Paravina RD. Color adjustment potential of resin composites. Clin Oral Investig [Internet]. 2018; 22(3): 1601-7.
https://doi.org/10.1007/s00784-017-2260-6

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