

Capacity of monochromatic composite resins to play a mimetic role for substrates with different shades

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Abstract

This study aimed to evaluate the mimicry potential of four monochromatic composite resins: Vittra APS Unique; Charisma Diamond One; Aura Bulk Fill and Palfique Omnicroma. Resins were tested on different substrate colors (A1, A2 and A3) and depths (1, 2 and 4 mm). The color was measured with a spectrophotometer and the ΔE calculated by the CIEDE 2000 system, as well as the color correspondence with the Vita Classical and 3D Master scales. The difference in color between the samples was verified using the two-way ANOVA test (resin and cavity depth), adopting a significance level of 5%. The Aura Bulk Fill resin statistically showed the lowest color variation in all groups, except for the A1 4mm group, in which the Charisma Diamond One and Palfique Omnicroma resins showed similar values. Meanwhile, the Vittra APS Unique resin statistically showed the greatest color variation in all groups, except for the A2 2mm group, in which it showed similar values to the Palfique Omnicroma resin. The evaluated composite resins better mimic lighter substrates and in shallower cavities. In a comparative analysis between the different commercial brands studied, it can be considered that the Aura Bulk Fill composite resin presented results significantly superior to the other materials, while the Vittra APS Unique presented statistically inferior results and the Charisma Diamond One and Palfique Omnicroma resins presented results similar to each other.

Keywords: color, composite resins, dental materials.

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Introdução

The evolution of resinous composites was highlighted when Buonocore presented the technique of acid etching of the enamel, improving adhesion to the tooth structure¹. In 1956, Bowen introduced Bis-GMA, which improved the properties of composite resins, expanding its indication². When it was proposed by Nakabayashi et. al.,³ the total acid etching of dentin and enamel and the adhesion process of composite resins to the tooth structure became more effective. Since then, up to the present day, composite resins have been widely studied and used in a variety of ways, becoming an indispensable material in clinical practice. The demand for esthetic and more conservative treatments has increased in the current routine of dental offices. Because of this, composite resin is a material that has been intensively researched with the aim of improving its characteristics in order to provide the esthetic result that is so much expected nowadays⁴.

However, in order to obtain the esthetic result expected by the patient, the professional is faced with one of the greatest difficulties when carrying out a restorative treatment: the choice of color. Matching the color of the restorative material with the dental substrate is still a challenge for many professionals. To obtain the expected esthetic result, it is necessary to have knowledge of color matching techniques and the use of different shades of resins, thus increasing the number of composite resins in the office, in addition to increasing the professional's clinical time⁵.

In view of this, monochromatic resins were created, which are materials that have a single color that promise to mimic different colors of dental substrates. These resins emerged with the main objective of facilitating the process of choosing the color during the restorative procedure, consequently reducing the amount of resins present in dental offices and the professional's clinical time^{6,7}. Thus, the objective of the present study was to evaluate the capacity of mimicking four different brands of monochromatic composite resins on different substrates and different cavity depths.

Materials and methods

Preparation of simulated cavities in resin for provisional purposes

The samples were made using twelve plates of the same size and different colors made from a Sonik 4k 3D Printer (Phrozen Technology; Hsinchu City, Taiwan). The material used was the PrintaX AA Temp temporary resin. Four plates were made in color A1, four plates in color A2 and four plates in color A3. Each plate has forty-eight simulated cavities all with the same 5mm diameter, sixteen of which are 1mm deep, sixteen are 2mm deep and sixteen are 4mm deep.

Preparation of restorations

Inside the prepared cavities, 37% phosphoric acid was applied for 30 seconds, after which they were washed with water to remove the acid and dried with an air jet. With the aid of a microbrush (FGM Dentscare Ltda, Joinville, SC, Brazil) of regular size, a layer of the adhesive corresponding to each brand of resin used was applied, as indicated by the manufacturers. The adhesives were applied as follows: Ambar APS (FGM Dentscare Ltda, Joinville, SC, Brazil) on the plates that received the Vittra APS Unique composite resin (FGM, Dentscare Ltda, Joinville, SC, Brazil); Stae (SDI Limited, Victoria, AU) on the plates that received the Aura Bulk Fill composite resin (SDI Limited, Victoria, AU); Palfique Bond (Tokuyama Dental Corporation, JP) on the plates that received the Palfique Omnichroma composite resin (Tokuyama Dental Corporation, JP) and Gluma Bond (Kulzer GmbH, Hanau, DE) for the plates that received the Charisma Diamond One composite resin (Kulzer GmbH, Hanau, DE) (Figure 1). The adhesives were applied according to the instructions of each manufacturer and soon after curing the adhesive for 20 seconds with Radium-Cal curing light (SDI Limited, Victoria, AU).

For the restoration of the cavities, the Vittra APS Unique (FGM Dentscare Ltda, Joinville, SC, Brazil), Charisma Diamond One (Kulzer GmbH, Hanau, DE), Palfique Omnichroma (Tokuyama Dental Corporation, JP) and Aura Bulk Fill (SDI Limited, Victoria, AU) composite resins in increments of no more than 2 mm were inserted into the cavity using a #6 resin spatula (Indusbelo, Indusbelo Company, Brazil). After placement and accommodation of each increment, photoactivation was performed for 40 seconds with a Radium-Cal curing light, according to the manufacturer's instructions. Prior to the polymerization of the last layer, a strip of polyester matrix was positioned on the restoration and pressed in order to remove any excess material and even out the surface. Finally, all restorations were polished with a felt disc and polishing paste (Diamond Excel; FGM Dentscare Ltda, Joinville, SC, Brazil).

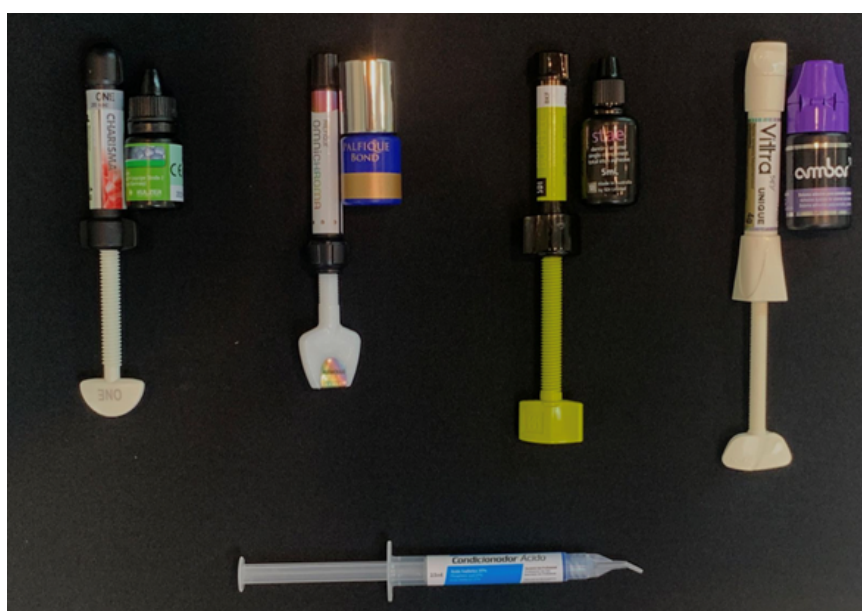


Figure 1. Composite resins used with their respective adhesives as indicated by the manufacturer.

Color analysis

Color measurement was performed with a reflectance spectrophotometer (VITA Easyshade® Advance 4.0 - VITA Zahnfabrik, Bad Säckingen, Germany), using the “Basic Color Measurement” mode by a trained operator. For the analysis, the measuring tip was rested on the surface of the sample, the measurement key was activated and the values of L*, a*, b* and L, C, H, were obtained after the complete measurement, in addition to the colors corresponding to the Vita Classical Scale and the Vita 3D Master Scale. Between measurements, the device was repositioned on the base so that its calibration could be carried out according to the manufacturer's instructions.

To calculate the ΔE value of the restorations in relation to the temporary resin plates, the CIEDE2000 system formula was used:

$$\Delta E_{00} = \left[\left(\frac{\Delta L'}{K_L S_L} \right)^2 + \left(\frac{\Delta C'}{K_C S_C} \right)^2 + \left(\frac{\Delta H'}{K_H S_H} \right)^2 + RT \left(\frac{\Delta C'}{K_C S_C} \right) + \left(\frac{\Delta H'}{K_H S_H} \right) \right] \frac{1}{2}$$

Statistical analysis

The results of the color analysis were expressed in a table with the value of ΔE_{00} , obtained by comparing the values measured on the temporary resin plates and composite resin restorations, based on the CIEDE 2000 formula. The difference in color between the samples was verified using the two-way ANOVA test (resin and cavity depth), adopting a significance level of 5%. The color correspondence with the Vita Classical and Vita 3D Master scale was expressed in a table.

Results

In the initial reading of the plates, the spectrophotometer identified different colors from those described by the manufacturer. In the temporary resin in colors A1, A2 and A3, the spectrophotometer identified colors B2, B3 and B4, respectively.

Regarding the color correspondence of the evaluated monochromatic composite resins and the temporary PrintaX AA Temp resin plates based on the Vita Classical scale, only the Aura A1 resin group at a depth of 2mm and the Palfique Omnichroma A1 resin group at a depth of 4mm showed similarity of color in all 16 analyzed samples (Table 1).

On the different composite resin brands for the same depth and color, the Aura Bulk Fill resin performed better in the A1 color with a depth of 1mm ($\Delta E = 3.8$) compared to the Charisma ($\Delta E = 8.1$), to the Palfique Omnichroma ($\Delta E = 9.3$) and to the Vittra APS Unique ($\Delta E = 12.2$). The Aura Bulk Fill resin also performed better in the A1 shade at 2mm depth ($\Delta E = 5.6$), relative to the Palfique Omnichroma ($\Delta E = 7.3$), Charisma Diamond One ($\Delta E = 8.4$) and Vittra APS Unique resins

($\Delta E = 23.5$). However, in the A1 color plate sample with a depth of 4mm, the Aura Bulk Fill, Charisma Diamond One and Palfique Omnichroma resins did not have a statistically significant difference between them. Only the Vittra APS Unique resin was inferior in the 4mm depth.

In the A2 color plate, it was possible to observe that at a depth of 1mm, the Aura Bulk Fill resin also performed better in relation to the other resins with a $\Delta E = 6.8$, Charisma Diamond One with a $\Delta E = 8.2$, Palfique Omnichroma with a $\Delta E = 10.1$ and with a $\Delta E = 12.1$ for the Vittra APS Unique. At a depth of 2 mm, the Palfique Omnichroma and Vittra APS Unique resins did not show a significant difference between them, but were shown to be inferior to the Charisma Diamond One and Aura Bulk Fill resins, respectively. At a depth of 4mm, the Aura Bulk Fill resin also performed better with $\Delta E = 8.2$. The Charisma Diamond One and Palfique Omnichroma resins did not show a significant difference, but with better performance than the Vittra APS Unique resin, which had the highest $\Delta E = 13.4$.

Table 1. Correspondence of the shade measured on the plate with the shade measured on the restoration according to the resin and substrate shade.

	A1 (B2 measured color)	A2 (B3 measured color)	A3 (B4 measured color)
Aura			
1mm	2/16	0/16	0/16
2mm	16/16	0/16	0/16
4mm	13/16	0/16	0/16
Charisma			
1mm	0/16	0/16	0/16
2mm	0/16	0/16	0/16
4mm	0/16	0/16	0/16
Omnichroma			
1mm	0/16	0/16	0/16
2mm	1/16	0/16	0/16
4mm	16/16	0/16	0/16
Vittra			
1mm	0/16	0/16	0/16
2mm	0/16	0/16	0/16
4mm	0/16	0/16	0/16

The Aura Bulk Fill Resin on the A3 plate also performed better at the 1mm, 2mm and 4mm depths. The Vittra APS Unique resin performed the worst on all A3 color samples at all depths. The Palfique Omnichroma resin was inferior only to the Aura Bulk Fill resin in the depths of 2mm and 3mm. In the 1mm sample, it did not show a significant difference in relation to the Charisma Diamond One resin.

Regarding the color of the restoration of the same brand of composite resin for different depths, it can be observed that the Aura Bulk Fill resin performed better in the 1mm depth for all three plates, mainly in the A1 shade. The Charisma Diamond One resin had its best performance at a depth of 4mm in shade A1, at 1mm in shades A2 and A3. The Palfique Omnichroma showed the best color match on the A1 2mm and 4mm plates, on the A2 1mm and 4mm plates and on the A3 1mm and 4mm plates. The Vittra APS Unique resin had its best performance in the A1 color plate with 2mm and 4mm; in the A2 color plate at 1mm and 4mm and in the A3 plate in the depth of 1mm and 4mm (Table 2).

Table 2. Color difference (CIEDE2000) according to plate color, resin and cavity depth.

		Aura	Charisma	Omnichroma	Vittra
A1	1 mm	3.8 ± 0.6 Aa	8.1 ± 0.4 Bab	9.3 ± 0.6 Cb	12.2 ± 0.6 Da
	2 mm	5.6 ± 0.6 Ab	8.4 ± 2.2 Cb	7.3 ± 1.7 Ba	23.5 ± 0.9 Db
	4 mm	7.5 ± 0.9 Ac	7.5 ± 1.1 Aa	7.3 ± 0.9 Aa	12.4 ± 0.6 Ba
A2	1 mm	6.8 ± 0.4 Aa	8.2 ± 0.4 Ba	10.5 ± 1.0 Ca	12.1 ± 0.5 Da
	2 mm	8.2 ± 0.6 Aab	10.1 ± 0.7 Bb	11.9 ± 0.7 Cb	12.4 ± 4 Ca
	4 mm	8.2 ± 0.8 Ab	10.6 ± 0.6 Bb	10.9 ± 0.5 Bab	13.7 ± 0.4 Cb
A3	1 mm	8.8 ± 0.4 Aa	10.7 ± 0.6 Ba	10.3 ± 0.3 Ba	13.3 ± 0.6 Ca
	2 mm	10.7 ± 1.2 Ab	12.1 ± 0.5 Cb	11.4 ± 0.4 Bb	16.9 ± 0.4 Db
	4 mm	11.2 ± 1.2 Ab	13.2 ± 0.4 Bc	10.3 ± 0.7 Aa	16.8 ± 0.7 Cb

Legend: Different lowercase letters indicate difference between resins for the same depth (line comparison). Different capital letters indicate the difference between the color of restorations at different depths (column comparison). Statistical tests: Two-way ANOVA (resin and cavity depth) using a significance level of 5%.

Discussion

Making imperceptible restorations is indeed one of the main challenges of restorative dentistry. This has been possible thanks to layering techniques, as well as the composite resins themselves, which have undergone modifications and improvements^{8,9}.

The present *in vitro* study aimed to evaluate the mimicry capacity of monochromatic resins in different substrates and depths. As in the work by Pereira et al.¹⁰, we opted to carry out an *in vitro* study with simulated cavities, given the difficulty of controlling variables when dealing with an *in vivo* study, such as the color of the substrate of the natural tooth, the depth and shape of the cavity. In view of this, the results of the present study must be analyzed with due caution since the simulated cavities were prepared in temporary resin, which has different optical properties, both from composite resin and from dental enamel.

The analysis of the final color of the restoration can be performed in different ways. However, the use of the digital spectrophotometer in the present study is due to the fact that it is

one of the most relevant methods in dental practice due to its objectivity and precision to measure the color variation of teeth, thus eliminating the subjective influence of the human eye¹¹.

The final color of the restoration is directly related to the color of the dental substrate and, in *in vitro* studies, in the same way, the analysis of the color of the samples is influenced by the background used in the analysis. However, this was not a limitation found in the present study since the materials used, according to the manufacturers, are capable of mimicking any substrate background whose color is in accordance with the Vita scale. Furthermore, all boards have been pre-tested with both the Vita Classical and Vita 3D Master scales¹².

In the work by Chen et al.,¹³ the Palfique Omnichroma composite resin was evaluated on substrates in colors A1, A2, A3 and A4, showing a better color combination on substrates A2 and A3 with the ΔE below the maximum value to be considered clinically acceptable. While in the present study, the Palfique Omnichroma resin showed a better color match on the substrate in the A1 shade.

As well as in the work of Iyer et al.,⁵ in which they compared the color correspondence through the instrumental and visual method of three composite resins, one of which was unichromatic (Palfique Omnichroma, Tokuyama Dental). The results showed that both in the instrumental evaluation and in the visual analysis, the Palfique Omnichroma resin showed a better combination with lighter tones, suggesting that single-color systems present better combinations in teeth with higher values⁵.

The Charisma Diamond One resin performed best on the A1 color plate at a depth of 4mm. According to the manufacturer, this composite resin uses “adaptive light matching” in which the shade is obtained by absorbing light reflected from the tooth. A previous study evaluated the color adjustment potential of Omnichroma, Charisma Diamond One, Vittra Unique and Essentia Universal composite resins in 2 mm deep and 7 mm diameter cavities and concluded that all tested materials presented acceptable color accuracy, without statistical difference between them¹⁴.

In the present study, the Aura Bulk Fill resin had a superior mimicry performance than the other tested brands. There is little scientific evidence related to this monochromatic resin, but due to the knowledge about “Bulk Fill” resins, whose objective is to fill cavities with increments of 4 or 5 mm in thickness since they have a lower polymerization contraction than traditional composite resins and more translucent colors that allow the passage of light for effective photoactivation¹⁵. Due to the fact that this resin allows a greater passage of light, it can explain the fact that it mimics the substrate better when compared to the other evaluated resins.

A study by Abdelraouf and Habib¹⁶ visually evaluated the color matching and mixing effect of a universal color composite resin placed on natural teeth. With the aid of a spectrophotometer, the color parameters were evaluated in the same way that seven observers evaluated them visually and, using numerical values, defined the color correspondence. In conclusion, they

realized that the monochromatic resinous material, when used *in vivo*, presents a satisfactory result, but it may not be the best option when there is a great need for esthetics.

An *in vitro* study carried out by Vinothkumar et al.,¹⁷ investigated the difference in color, translucency and color assimilation of a monochromatic composite resin and other five Vita shades of conventional resins. It was concluded that the monochromatic resin obtained a color difference in all shades tested, however, it showed high translucency and permissible color assimilation of both anterior and posterior models. Also, the Vittra Unique APS composite resin has better mimicry potential in shallower cavities and lighter colored substrates, which is possibly explained by the greater translucency in these situations¹⁸.

Due to the color incompatibility problem of the different traditional composite resins in relation to the Vita Classical scale^{19,20}, making the restorative procedure more difficult, several companies have started to manufacture universal resins with a single tone that promise to mimic the dental substrate. The objective is to promote greater color compatibility between the restorative material and the remaining tooth. However, the study by Abreu et al.,²¹ demonstrated that this new generation of resins presented worse results when compared to traditional resins.

There are still few *in vitro* studies related to the Vittra APS Unique resin, Charisma Diamond One and Aura Bulk Fill, and mainly *in vivo* studies. The Palfique Omnichroma resin was the one with the highest number of articles published in the literature. It was difficult to find other articles that list different brands of monochromatic resins. For these reasons, it is necessary to carry out more studies on the aforementioned materials, mainly *in vivo* studies.

Conclusion

The present study concluded that all the composite resins analyzed presented a distinct coloration of the substrate, which was dependent on the color and depth. Among the four resins tested, the Aura Bulk Fill resin had the best mimicry capacity in all substrate depths and colors, mainly in the lighter and shallower substrate.

Resumo

O presente estudo teve como objetivo avaliar o potencial de mimetização de quatro resinas compostas monocromáticas: Vittra APS Unique; Charisma Diamond One; Aura Bulk Fill e Palfique Omnichroma. As resinas foram testadas em diferentes cores de substrato (A1, A2 e A3) e profundidades (1, 2 e 4 mm). A cor foi mensurada com espectrofotômetro e o ΔE calculado pelo sistema CIEDE 2000, bem como a correspondência de cores com as escalas Vita Classical e 3D Master. A diferença de cor entre as amostras foi verificada por meio do teste ANOVA de dois fatores (resina e profundidade da cavidade), adotando-se nível de significância de 5%. A resina Aura Bulk Fill apresentou estatisticamente a menor variação de cor em todos os grupos, exceto no grupo A1 4mm, no qual as resinas Charisma Diamond One e Palfique

Omnichroma apresentaram valores semelhantes. Já a resina Vittra APS Unique apresentou estatisticamente a maior variação de cor em todos os grupos, exceto no grupo A2 2mm, no qual apresentou valores semelhantes à resina Palfique Omnichroma. As resinas compostas avaliadas mimetizam melhor substratos mais claros e em cavidades mais rasas. Numa análise comparativa entre as diferentes marcas comerciais estudadas, pode-se considerar que a resina composta Aura Bulk Fill apresentou resultados significativamente superiores aos demais materiais, enquanto a Vittra APS Unique apresentou resultados estatisticamente inferiores e as resinas Charisma Diamond One e Palfique Omnichroma apresentaram resultados semelhantes entre si.

Palavras-chave: cor, resinas compostas, materiais dentários.

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