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INSTRUMENTAL AND VISUAL COMPARISON OF COLOR MATCHING OF TWO UNIVERSAL SHADE RESIN COMPOSITES IN DIFFERENT THICKNESSES VERSUS A2 VITA CLASSICAL SHADE

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ABSTRACT

Objectives: To evaluate and compare the color matching of two universal shade commercially available composite materials in different thicknesses with A2 Vita classical shade bi-layered acrylic lower molar teeth, instrumentally and visually.

Methodology: Forty bi-layered acrylic right mandibular first molars of A2 Vita classical shade were divided into two groups randomly according to assessment method (n = 20 teeth). Twenty teeth were used for instrumental assessment, they were randomly divided into 4 subgroups n=5; (Ins-XF2) subgroup: circular cavities were prepared in occlusal surfaces with 2mm depth and 6 mm diameter then restored with X-Tra Fil (Ins-XF4) subgroup: circular cavities were prepared in occlusal surfaces with 4 mm depth and 6 mm diameter then restored with X-Tra Fil composite. (Ins-OM2) subgroup: circular cavities were prepared in occlusal surfaces with 2mm depth and 6 mm diameter then restored with Omnichroma composite. (Ins-OM4) subgroup: circular cavities were prepared in occlusal surfaces with 4mm depth and 6 mm diameter then restored with Omnichroma composite. All restored surfaces for instrumental assessment were flat in shape. Color parameters were recorded using digital contact spectrophotometer, and then the total color difference ΔE were calculated. For visual analysis; the other twenty teeth were divided, prepared in the same previous manner. But the teeth were restored in anatomical occlusal form. Ten blinded observers with normal color-vision evaluated each restored tooth; and rank the degree of color-matching visual scoring. All results were expressed numerically. Data was recorded and statistically analyzed.

Results: Instrumental analysis of X-Tra Fil and Omnichroma showed no statistically significant difference of ΔE between 2mm & 4mm restorations. Omnichroma recorded significantly lower ΔE and higher visual scoring than that of X-Tra Fil.

Conclusions: Within the limitations of this study, Omnichroma composite resin showed lower ΔE values and better visual scores in relation to X-Tra Fil one.

KEYWORDS: Resin composites, Spectro-photometer, Universal shade, Color matching.

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INTRODUCTION

Recently, composites have been considered the restoration of choice for anterior teeth and many posterior teeth as well. To replace any destroyed part of tooth structure, there are many objectives to be properly fulfilled by the dentist; tooth form, function, and aesthetics are the primary ones. Within many factors, the most important factor that ensures an aesthetic outcome of the restorative material is the presence of non-detectable, perfect color match. [1] According to the 16 VITA Classical Shades A1–D4, most of the commercially available composite resins are presented in multiple shades of differing translucencies. Using such shades to restore polychromic missing tooth structure commonly requires too long chair-side time and high cost, and it depends on the experience level of clinicians. So, matching the color of the resin composite with the surrounding tooth structure is considered a challenging process, which is complicated by varying tooth color according to tooth site, patient age, and the type of the restored tooth. [2, 3] The chameleon effect is a term that describes the ability of a material to acquire a color resembling that of adjacent and surrounding tooth structure; this effect may also be known as the ''Blending effect''. The material that has such an effect can mimic the color of the surrounding tooth structure, irrespective of its shade.

The commercially available dental resin based composites can be classified into main three groups according to the available shades. Firstly, single-shade composite; which has been used as a single universal shade and it has a great ability to blend with all 16 VITA classical shades, thus matching the shade of every tooth color. Secondly, group-shade composite; this composite system is presented in fewer numbers of shades, but each shade can be used instead of a group set of the classical 16 VITA shades, it is also called a cloud shade. Finally, multi-shade composite; is a conventional composite system that has a separate composite shade for each of the 16 VITA classical shades. [2]

Omnichroma is a newly developed single-shade resin composite (Omnichroma; OMN, Tokuyama Dental, Tokyo, Japan), which was introduced recently in the markets to minimize the dependence on clinicians' skills for color matching and providing speedy treatment for patients. [3-5] However, X-tra Fil is a posterior, universal shade bulk-fill composite that allows the clinician to cure 4 mm layers. Multi-hybrid technology is the backbone of this contemporary composite.[6]

Among the most accurate, useful and versatile tools for matching colours in dentistry are spectrophotometers. In 93.3% of cases, spectrophotometers achieved a more objective match and a 33% increase in accuracy when compared to human-eye observations or traditional methods.[7]

Sanchez et al. [8] evaluated Omnichroma instrumentally and visually for color adjustment potential (CAP). They found that Omnichroma as a single-shade composite material had better and more positive CAP across the 16 VITA classical A1-D4 shades than the other four materials that had been developed for specific shades. This means that Omnichroma [OM] has the ability to blend in with the surrounding tooth structure and reduce any color differences between them. Abdelraouf et al. [5] assessed the degree of color matching and blending effect of (X-TraFil) universal shade composite in natural teeth and in different composite models with variable shades, and different cavity sizes. They found that X-TraFil had more satisfactory results when tested on natural teeth. The null hypothesis of this study was that there would not be a difference in instrumental and visual analysis of color matching between the two universal shade commercially available composite materials in different thicknesses with A2 Vita classical shade bi-layered acrylic lower molar teeth.

To the extent of our knowledge, single-shade composites are not well supported by empirical data.[9] Thus, this study aimed to evaluate and compare the color matching of two universal shade commercially available composite materials with bi-layered A2 Vita Classical shade acrylic teeth; instrumentally and visually.

MATERIALS AND METHODS

Manufacturer, composite type, filler content, matrix composition, technique, and shade of the two evaluated resin-composites are listed in (Table.1).

In this study, the color matching of two commercially available universal shade resin-based composite materials, namely, X-Tra Fil (XF) and Omnichroma (OM), were evaluated and compared relatively to bi-layered acrylic teeth of A2 Vita classical shade (provided by Tokuyama Dental, Japan). According to the manufacturers, both X-Tra Fil and Omnichroma materials are considered as single-shade materials, with composition and optical characters that enable them to match and blend in with any spectrum of tooth color, from A1 to D4.

Sample size:

A total of 5 specimens in each group were calculated as the sample size, based on the results retrieved from earlier research (Sanad et al., 2022). The calculation was done using G*power version 3.0.10, with an effect size of 1.26, a 2-tailed test, α error = 0.05, and power of 80.0%.[9]

Samples Preparation:

Forty bi-layered acrylic right mandibular first molar of A2 Vita classical shade were used in this study to evaluate the color match of two commercially available universal shade resin-based composites, namely, X-Tra Fil (XF) and Omnichroma (OM). The choice of bi-layered acrylic teeth was mainly to replicate as possible as natural teeth enamel and dentin layering and this make the color readings more realistic. The teeth were randomly divided into two groups according to assessment method (n = 20 teeth).

Instrumental assessment of color difference:

Twenty teeth were used for instrumental assessment, before any teeth preparations, numbers from 1 to 20 were written on the under surfaces of these teeth to allow a further random distribution into four subgroups assigned for instrumental analysis. Baseline readings of the three color parameters (L, a, and b values) were measured on buccal surfaces of such unprepared bi-layered acrylic teeth using a digital contact spectrophotometer (VITA Easyshade V, VITA Zahnfabrik, Bäd Sackingen, Germany). These color parameters were recorded by placing the measuring tip of spectrophotometer perpendicular to the buccal surface. These recorded data were individually saved according to each tooth number.

TABLE (1) Product, manufacturer, composite type, filler content, matrix composition, technique, and shade of used resin-composites.

Product	Manufacturer	Composite type	Filler content % wt.	Matrix composition	Technique	Product Shade
X-Tra Fil	Voco, Cuxhaven, Germany	Hybrid	86%	Bis-GMA* UDMA** TEGDMA***	Bulk-fill	Universal shade
Omnichroma (OM)	Tokuyama Dental Tokyo, Japan	Supra-Nano	79%	UDMA** TEGDMA***	Layered-technique	Universal shade

**** Bis-GMA: bisphenol A glycidyl dimethacrylate; ** UDMA: urethane dimethacrylate; and *** TEGDMA: triethylene glycol dimethacrylate.***

Then, teeth were randomly divided into 4 subgroups n=5; **(Ins-XF2) subgroup:** circular preparations with 2mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with X-Tra fil composite. **(Ins-XF4) subgroup:** circular preparations with 4mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with X-Tra fil composite. **(Ins-OM2) subgroup:** circular preparations with 2mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with Omnichroma composite. And finally, **(Ins-OM4) subgroup:** circular preparations with 4mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with Omnichroma composite. **(Fig.1)**

The depth of all preparations was measured from the lingual grooves between lingual cusps on the occlusal surfaces. Following the manufacturer's instructions, the prepared teeth in each subgroup were restored to a flat surface **(Fig.2),** using their corresponding composite material, and light cured for 20 seconds using LED light curing unit (Bluephase II, Ivoclar Vivadent) at an energy level between 1100 and 1300 mW/ cm^2. During the experiment, the output intensity was constantly monitored using a radiometer (Bluephase Meter II, Ivoclar Vivadent, Amherst, New York). After curing, all composites were finished into flat surfaces using 12-flute finishing burs (Prisma finishing burs, Dentsply, York, Pennsylvania) and were polished under light pressure for 40 seconds using polisher point (PoGo, Dentsply, York, Pennsylvania).

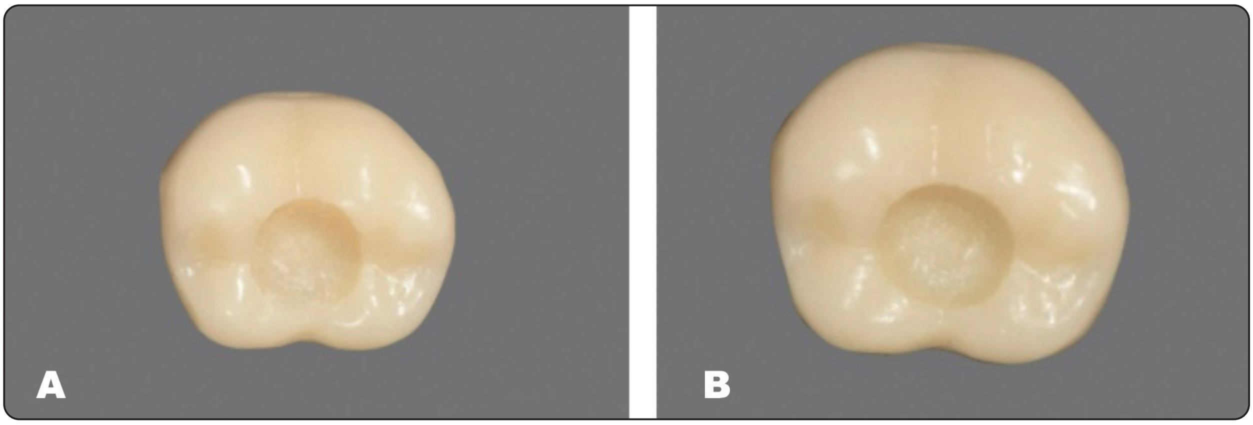

Fig. (1) Occlusal preparations for Instrumental assessment (A) 2mm depth & (B) 4mm depth.

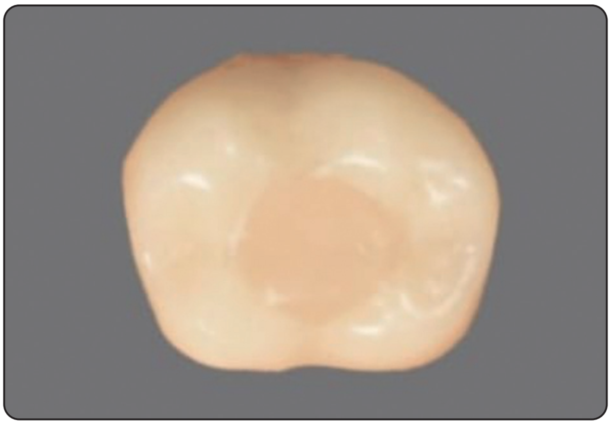

Fig. (2) Flat occlusal restoration for instrumental assessment.

Two important factors were considered during color measuring, **firstly**; neutral grey paper was used as a background during measurements. **Secondly**, the device of spectrophotometer should be calibrated after every three measurements. [2] During entire instrumental assessment, three readings were taken for each measurement, and then an average of such readings was registed as a single data point.

The total color difference ΔE between the two universal shade composite (X-Tra Fil & Omnichroma) in both thicknesses, and the bi-layered A2 Vita Classical shade acrylic teeth were calculated according to the following equation:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where ΔE is corresponding to total color difference, while L*, a*, b* are the CIELAB color coordinates. [5] ΔL*, Δa*, and Δb* correspond to differences in lightness (L*, achromatic coordinate), (a*, green-red coordinate), and (b*, blue-yellow coordinate), respectively

Visual assessment of color difference

The remaining twenty teeth were used for visual assessment. Silicon occlusal stamp was prepared before any cavity preparations in these teeth. Then the teeth were randomly divided into 4 subgroups in the same manner followed for instrumental assessment. **(Vis-XF2) subgroup:** circular preparations with 2mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with X-Tra fil composite.**(Vis-XF4) subgroup:** circular preparations with 4mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with X-Tra fil composite. **(Vis-OM2) subgroup:** circular preparations with 2mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with Omnichroma composite. Finally, **(Vis-OM4) subgroup:** circular preparations with 4mm depth and 6 mm diameter were cut in the occlusal surfaces and teeth were restored with Omnichroma composite.

In the previously mentioned four subgroups, both types of composites were restored anatomically **(Fig.3)** by pressing the preformed occlusal stamp against composite after packing into the cavities. Curing, finishing and polishing were performed as previously described in instrumental assessment. In order to visually assess the degree of color matching between the color of two universal shade composites in both thicknesses, and bi-layered A2 Vita Classical shade acrylic teeth, the anatomically restored teeth were firstly divided according to the depth of restoration, then they were randomly arranged and placed on a neutral grey paper to be viewed with D65 illuminate at an angle of 90° to the occlusal surfaces. Ten blinded observers (five dentists and five nurses) with normal color-vision evaluated each

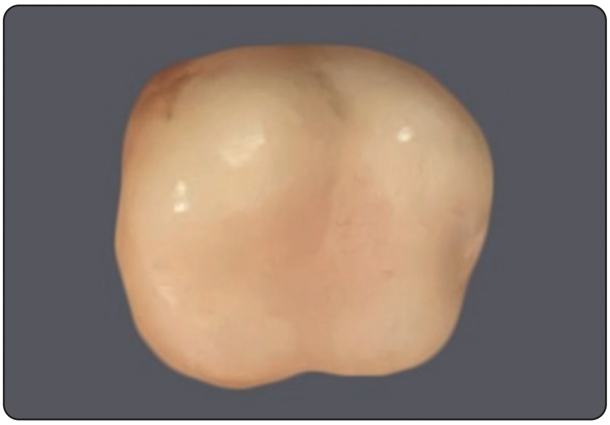

Fig. (3) Anatomical occlusal restoration for visual assessment.

restored tooth; each observer had 25 seconds to rank the degree of color-matching between composite restoration and tooth. The color-matching visual scoring values were an average of the ten observer scores. These scores were expressed numerically as the following: **1**: mismatch/totally unacceptable, **2**: Poor-Match/hardly acceptable, **3**: Good-Match/acceptable, **4**: Close-Match/small-difference, and **5**: Exact-Match/no-color-difference. All observers were tested for color deficiency using Ishihara's Test for Color Blindness.[10] Before the beginning of assessment, all observers were trained perfectly on color-matching and taught how to use the grading system. To avoid eye fatigue, after examination of each restored tooth, the observers were instructed to look at a neutral blue background.

Statistical Analysis

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW statistics for windows version 25. Chicago: SPSS Inc.). Qualitative data were described using number and percent. Quantitative data were described using mean± Standard deviation for normally distributed data after testing normality using Shapiro Wilk test. Significance of the obtained results was judged at the (≤0.05) level. Student t test was used to compare 2 independent groups for non-normally distributed data. Two Way ANOVA test was used to study the combined effect of 2 independent factors on dependent continuous outcome with estimation of R^2.

RESULTS

Instrumental analysis of teeth restored with X-Tra Fil resin composite material, showed no statistically significant difference of ΔE between subgroups (Ins-XF2) and (Ins-XF4). The mean values were (8.10±0.35 & 8.38±0.42) respectively P = 0.288. Also, Instrumental analysis of teeth restored with Omnichroma resin composite material had a non-statistically significant difference of ΔE between the two subgroups (Ins-OM2 and Ins-OM4). The mean values were (7.48±0.34 & 7.80±0.22) respectively P = 0.118 **(Table. 2)**.

Visual scoring was in accordance with instrumental analysis as there were no statistically significant differences of measured visual scores between the teeth restored with X-Tra Fil resin composite in both thickness, mean scores were 3.2±0.84 & 3.4±0.55 for Vis-XF2 and Vis-XF4 subgroups respectively and p=0.667. Also, for teeth restored with Omnichroma, the differences between Vis-OM2 (4.6±0.55) and Vis-OM4 (3.8±0.84) subgroups were non-significant p=0.111 **(Table. 3)**.

According to the results of the present study, OM in both evaluated thicknesses showed better results than XF (lower **ΔE** and higher visual scoring), and all the differences were significant, except the visual scoring of Vis-XF4 and Vis-OM4 specimens, the difference was non-significant p=0.397 but Vis-OM4 is still better **(Table. 4 & Table. 5)**. Regardless the type of composite material, this study showed non-statistically significant differences in **ΔE** and visual score between 2mm and 4mm restoration thickness, as P=0.155 & 0.445 respectively. But, restorations in 2mm thickness showed better results i.e. lower **ΔE** and higher visual scoring **(Table. 6).**

TABLE (2) Comparison of ΔE between different measurements within each Composite.

Composite materials	ΔE		Test of significance	
X-Tra Fil	Ins-XF2 8.10±0.35	Ins-XF4 8.38±0.42	t=1.14	p = 0.288
Omnichroma	Ins-OM2 7.48±0.34	Ins-OM4 7.80±0.22	t=1.75	p =0.118

t: Student t test , *statistical analysis

TABLE (3) Comparison of visual score between different measurements within each Composite.

Composite materials	Visual Scoring		Test of significance	
X-Tra Fil	Vis-XF2 3.20±0.84	Vis-XF4 3.40±0.55	t=0.447	p=0.667
Omnichroma	Vis-OM2 4.60±0.55	Vis-OM4 3.80±0.84	t=1.79	p=0.111

t: Student t test , *statistical analysis ***t:Student t test , *statistical analysis***

TABLE (4) Comparison of ΔE between different composite materials.

Restoration thickness	ΔE of different composite		Test of significance	
2mm Restoration	Ins-XF2	Ins-OM2	t=2.82	p=0.023*
	8.10±0.35	7.48±0.34		
4mm Restoration	Ins-XF4	Ins-OM4	t=2.72	p=0.026*
	8.38±0.42	7.80±0.22		

*t: Student t test , *statistical analysis*

TABLE (5) Comparison of visual score between different composite materials.

Restoration thickness	Visual scoring of different composite		Test of significance	
2mm Restoration	Vis-XF2	Vis -OM2	t=3.13	p=0.014*
	3.20±0.84	4.60±0.55		
4mm Restoration	Vis -XF4	Vis -OM4	t=0.894	p=0.397
	3.40±0.55	3.80±0.84		

TABLE (6) Comparison of ΔE and visual scores between different thicknesses of resin material

Thickness	2mm	4 mm	Test of Significance	
ΔE	7.79±0.46	8.09±0.44	t=1.48	p=0.155
Visual Score	3.90±0.99	3.60±0.69	t=0.780	p=0.445

*t: Student t test , *statistical analysis*

DISCUSSION

In vitro evaluations and studies should be applied to test the clinical performance of any newly developed restorative material.[12] Composites are widely used as anterior restorative materials because they have excellent appearance, conservative characters, low cost, and good mechanical properties. Many manufacturers fabricate composites in multiple shades, following the Vita Classical shade guide, in order to match the great variations in the color of natural teeth.[13, 14] Nowadays, resin composites are widely used as direct aesthetic restorative materials in both anterior and posterior teeth. This is because of the great improvement in physical and mechanical properties as well as the perfect cosmetic appearance associated with newer filler technology. But one should know that tooth color is affected by many factors, such as position in the oral cavity, tooth type, and patient age. These factors make matching the color of the resin composite with the surrounding tooth structure a challenging procedure.[1] The procedure becomes more complicated by the presence of many factors that can affect the composite shade, such as filler percentage, filler size, matrix composition, restoration size, layering of the composites, and the brand and shade of the composite itself. [2] Mainly, there are two techniques for building composite restorations; layering and bulk-fill techniques. Layering technique was developed since 1980s, in attempting to simulate the optical properties of a natural tooth by building the composites in multiple layers; each layer has different chromas and opacities. Although, layering technique yielded adequate results for color matching, but, it is considered to be more complicated than one or two shade technique, requiring higher technical skills and longer chair-side time. [7, 15]

Although there are multiple techniques available to evaluate the degree of color matching between tooth structure and restorations, there are two different methods (the instrumental method by measuring of (ΔE) and the visual method) which are the most commonly used methods.[1,16] One should differentiate between perceptibility and acceptability, as perceptibility refers to the presence of color difference between a restoration and adjacent tooth structure, whereas acceptability refers to the degree of acceptance by the human eye of the color of that restoration. Nowadays, the CIEDE2000 is the most accepted formula to evaluate ΔE. [17, 18]

A contact spectrophotometer is used in the instrumental method and is characterized by having standardized and perfectly integrated illumination (6500 K). Also, spectrophotometers have the ability to measure both the amount and spectral composition of reflected light from any object and then convert it into quantifiable data. Many authors recommended spectrophotometers and considered them to be better and more reliable than colorimeters, as they are not affected by object metamerism.[2,19] The intraoral spectrophotometer used in this study is the VITA Easyshade V. This device provides a great degree of reliability and accuracy. For color matching, it uses a 5-mm probe tip to illuminate the tooth with a 6500 K light and then displays the results as L*, a*, and b* values. Among five commercially available devices, VITA Easyshade V was found to be the most precise device in both in vitro and in vivo evaluations.[20, 21] Some authors considered the VITA Easyshade V the only color measuring device that had more than 90% reliability and accuracy in measurements. [22, 23]

In this study, both evaluated universal shade composites showed an increase in ΔE values by increasing the thickness of the specimens from 2mm to 4mm, but the differences were non-significant. The better aesthetic properties of composites in thinner sections in this study are in agreement with Paravina et al. [22], as they concluded in their work that the blending effect (BE) of composites increased with a decrease in restoration size.

In this work, the ΔE values of Omnichroma varied from 7.48±0.34 to 7.80±0.22 according to the specimens' thicknesses of 2mm and 4 mm, respectively. This is in agreement with Iyer et al. [2], as they found the ΔE values of OM to be 8.02 ±0.44. The better color matching of the single-shade composite material OM (lower ΔE and higher visual scoring) is in agreement with Sanchez et al. [8], as they found that OM had a more positive (CAP) color adjustment potential and better blending in effect with the surrounding tooth structure than the other evaluated materials, which had been developed for specific shades. Although Easy shade V is not specified for recording the different shades of composite, but it was the best instrument to determine L*, a*, and b* readings.

The visual scoring of OM is in accordance with its instrumental analysis, as (Vis-OM2 & Ins-OM2) subgroups had a better results (4.60±0.55 & 7.48±0.34) than (Vis-OM4 and Ins-OM4) subgroups (3.80±0.84 & 7.80±0.22); but the differences were non-significant. On the other side, the visual scoring of X-Tra Fil were slightly varied from their instrumental analysis, as ΔE in (Ins- XF2) subgroup was 8.10±0.35 which is lower than ΔE in (Ins- XF4) subgroup 8.38±0.42, but visual score of Vis-XF4 (3.40±0.55) was higher than Vis –XF2 (3.20±0.84). This may be explained by the difference in curing method, as OM is incrementally cured, which ensures a more uniform polymerization reaction than bulk-fill X-Tra Fil composite. Besides, the presence of more than one observer made the achievement of a repeatable result impossible. Chu SJ et al. [23] added that the numerical reduction in ΔE value does not necessarily correspond to better color match because there was uneven eye sensitivity to the differences in hue, value, and chroma.

According to Paravina et al. [24] Omnichroma contains no pigments, and the majority of its color properties depend on the structural color and smart chromatic technology. This resin composite can respond to any light wave frequency by accurately reflecting a precise wavelength inside the tooth. This allows good color matching to all VITA classical A1-D4 shades with only a single-shade resin composite.

CONCLUSION

Within the limitations of this study, Omnichroma composite resin showed lower **ΔE** values and better visual scores in relation to X-Tra Fil one. In most common cases, the reduction in the thickness of specimens is associated with better results.

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