Color Match Clinical Evaluation and Patients' Acceptability for a Single Shade Universal Resin Composite in Class III and V Anterior Restorations

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Abstract

This study evaluated the capability of a single shade universal resin composite [Omnichroma® (OMRC)] to match the tooth color. Forty-five conservative cavities (Class V and III) were prepared in a total of 21 patients. The adhesive system and OMRC were applied according to the manufacturer instructions. After 60min. of restoration placement, the color the of restoration and the tooth were recorded using a digital spectrophotometer. Color-matching visual scoring (VS) was also done by two PhD-students. Patients' acceptability of the restoration was done using Likert 5-point scale. Data were statistically analyzed using paired t-test, significance level was set at $P \leq 0.05$.

Results revealed that there was a statistically significant change in the brightness (ΔL) ($p < 0.001$), while no significant difference in the a* and b* parameters between the restorations and the teeth were shown. Color changes of the restorations compared to the teeth (ΔE) ranged from 2.01-8.54 (5.14±1.38). VS showed more than 70% of the cases clinically unacceptable by both observers. More than 80% of the patients showed neutral to satisfied acceptability for the restorations.

It was concluded that OMRC showed poor clinical color matching values in anterior teeth and were unacceptable to the PhD dental students. There was a high acceptability level among the patients for OMRC.

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Introduction

Matching the color of resin composite utilized in anterior teeth is a challenging task facing dentists in daily practice. The tooth color is primary influenced by its dentin[1]. On the other hand, enamel has a major effect on lightness color perception. In the layering concept, the missed dental tissues are substituted with resin composite applied in increments. A translucent composite resin is used to cover a more opaque composite resin to attain a depth perception same as that of the natural teeth[2,3], which indicates that the visible color is the consequence of diffuse reflectance from the internal dentin or opaque material layer through the external translucent layer [4].

There are numerous elements that make the color matching problematic. These problems arise from the point that color matching rely on many different chromatic properties related to the teeth and resin composite; those include hue, chroma and value; translucency, opalescence and fluorescence; light diffusion and transmission; and luster and texture of the surface[5,6]. To reach the ideal esthetics, restorative material should mimic the natural tooth in the previously mentioned properties, in addition to the long time color stability[7].

Over the years, efforts are exerted to improve the esthetic properties of resin composite restorative materials. Lately, a single shade structurally colored universal composite (Omnichroma, Tokuyama Dental) intended for use with most direct restorative clinical cases was introduced in the market. Its manufacturer claimed that it has the ability to color change toward the color of the surrounding hard dental tissues. Thus, it can improve the esthetic

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appearance of the restoration, decrease the dependence on multiple shade-matching procedures [8], decrease the number of shade guide tabs, and to some extent, it can counteract for color mismatches [4, 9].

Laboratory studies are vital for the initial assessment of the restorative material, however a clinical study may reflect all the variables influencing the performance of different restorations [10]. Extracted nonvital teeth used in the laboratory studies have structural alteration than vital ones, thus evaluating the color match of fillings in patients' mouth is an essential step.

Thus, the aim of current study was to clinically evaluate the color matching of a single shade universal composite in class III and V restorations using digital and visual evaluation methods. Moreover, patients' acceptability for the color match of the restorations to the tooth structure was assessed. The null hypothesis states that there was color matching between the single shade universal resin composite and the teeth.

Materials and methods

Trial registration and ethical approval:

The trial was registered in ClinicalTrials.gov under the identification number (NCT04960852). All participants signed an informed consent before joining this study, in full accordance with the World Medical Association Declaration of Helsinki [11]. Ethical approval was obtained from the Ethical Research Committee - National Research Centre (NRC), Cairo, Egypt (Ref number: 3433042021). All participants had read and signed a consent form before enrollment in the present study.

Sample size calculation:

Using Clincalc sample size calculator for intervention study; with 0.05 alpha error and power of the study 0.80, enrollment ratio of 2. to calculate minimal sample size needed for assessment of color shade-matching of a composite restorative material in the patients' mouth., as reported in literature: Differences in color between tooth and restoration were 82.36±4.82 and 87.17±2.09 for L*, 1.83±0.7 and 0.86±049 for a*, 30.05±2.32 and 22.21±2.75 for b* respectively in both groups[4]. The sample size calculated was 45 teeth with class V and/or class III cavities.

Participants' recruitment:

The patients were selected from outpatient clinic of National Research Centre (NRC), Cairo; Egypt. Patient risk assessment using American Dental Association® **(ADA)** caries risk assessment form (Ages > 6) were carried out for all selected patients to be categorized into low or medium risk category. Radiographical assessment was also performed to exclude any patient with any sign of periapical pathosis.

Eligibility criteria:

Eligibility criteria for patients: 21 participants with ages ranged from (16-45) years were enrolled in the current study following the inclusion and exclusion criteria.

- **Inclusion criteria**:
  - Patients with carious class V and/or small class III (with palatal wall) lesions
  - Young adult males or female
  - Patient with low or moderate caries risk index
  - Co-operative patients approving to participate in the study
- **Exclusion Criteria**:
  - Patients with a compromised medical history
  - Severe or active periodontal disease
  - Severe medical complications
  - Erosive lesions
  - Lack of compliance and rampant caries
  - Patients with smoking habits

Clinical procedure

- **Cavities preparation**

At first, each patient received scaling and polishing procedures (Proxyt RDA 83; Ivoclar Vivadent, Liechtenstein) to clean the teeth surfaces.

A total of 45 cavities were prepared on 35 anterior maxillary teeth and 10 mandibular teeth in a total of 21 patients. Appropriate local dental anesthesia (Mepecaine-L) 1mg had been injected preoperatively unless declined by the patient. Treated teeth were isolated with OptraDam® Plus rubber dam (Ivoclar Vivadent, USA) and saliva ejector.

Conservative cavities were prepared with #330 high speed carbide bur (FG, Dentsply Midwest®, Germany) using water coolant. Cavity preparation was limited to the removal of caries and the exact cavity form and size were obtained

after complete caries removal. Each bur was discarded every five cavity preparations [12].

A 75-degree bevel functional esthetic enamel bevel [13] was prepared using a fine grained finishing diamond rotary instrument (Brasseler, USA) on the facial surface of class III cavities, to enables harmonious shade transition from resin composite to the tooth substance.

A 45-degree bevel was placed on the incisal wall of the prepared class V cavities [4]. The prepared cavities were then rinsed with copious amount of water to ensure removal of all debris. Then the cavities were blotted using sterile cotton pellets.

- **Application of the adhesive system and resin composite**

Enamel of the prepared cavities was etched using Meta etchant gel (Meta Biomed, Germany) for 30s. After rinsing with water and air drying, the bonding agent [Bond Force; One component, self-etching adhesive (Tokuyama Dental Tokyo, Japan)] was applied according to the manufacturer's instructions to the cavity walls with a rubbing action for 20s using a micro brush, then weak air-thinned for 5s, followed with strong air-thinning for 5s and finally light-cured for 10s using light curing unit at intensity of 600 W/cm^2. Omnichroma resin composite [light-cured, radiopaque single shade universal composite (Tokuyama Dental, Tokyo, Japan)]was packed in the prepared cavities using a Teflon instrument and the restoration was covered with celluloid strip to eliminate the oxygen inhibition layer and to get a smooth surface, then light-cured for 20s. Excess material was removed with a sharp scalpel. Finishing and polishing were performed for the anatomical contouring and smoothing of the restoration's surfaces using soflex discs (3M ESPE, USA) of different grits, fine and extra fine diamond burs, finishing strips (Jiffy Diamond Strips, Ultradent, USA), and medium and fine rubber polishing points (Jiffy Polishers, Ultradent, USA).

Color assessment

After restoring each tooth, the rubber dam was removed and the tooth was allowed to rehydrate for 60 min [14]. Color measurements was determined in dental office with dental light and natural light source (next to the window) (light temperature 6500 K, illuminance 1000 lux) [15], using intraoral spectrophotometer VITA Easyshade® V (VITA Zahnfabrik, Bad Sackingen, Germany). Light temperature and illuminance measurements were performed using colorimeter Chroma-2 (Lisun Electronics, Shangai, China).

Two color measurements were performed: one toward the center of the restoration, and another measurement was taken toward the tooth surface, right next to the tooth/restoration interface, 1 mm away from the margin, to minimize possible alterations due to the reflected light at the surface[16].

The shade-matching device was calibrated and operated according to the manufacturer's instructions. The heads of the subjects were placed against the headrest of the treatment chair and their mouths were slightly open during the measurement with the tongue away from the teeth.

The teeth and restorations were gently dried with cotton and the color values of the them were recorded using the Vita Easyshade spectrophotometer. The probe tip of the intraoral spectrophotometer was positioned perpendicular and flushed onto the tooth or the restoration surfaces 1mm away from the tooth/restoration interface to get correct measurements.

The color changes (ΔE) were calculated from the changes in CIE L, a, and b values (ΔL, Δa, Δb) as follows:

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

CIE Lab is expressed by the L coordinate representing color luminosity, varying from white to black, a and b coordinates representing the chromaticity of the color, with axes varying from green to red and blue to yellow, respectively. The mean of the values obtained were calculated, and the L, a, and b parameters were determined.

Visual color match assessment

Visual assessment was performed by two independent observers (PhD dental students) with normal color vision as checked by Ishiara test. The visual color match assessment procedure was performed in the same visit of the restoration placement under the conditions stated by Abdelraouf and Habib [17]. To determine the color-matching between the restorations and the teeth, color-matching visual scoring (VS) values were expressed numerically as follows [17]: 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. Observers were trained in color-matching and taught about the used grading system before the assessment.

Patients' acceptability of the restoration

Evaluation criteria for patients' acceptability of the restoration color match with the tooth was done using Likert 5-point scale [18]. In which Score 1: Very dissatisfied; Score 2: Dissatisfied; Score 3: Neutral; Score 4: Satisfied; Score 5: Very satisfied.

Statistical analysis

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, color data showed parametric (normal) distribution while VS data showed non parametric (abnormal) distribution. For parametric data; Paired sample t-test was used to compare between two groups in related samples. Independent sample t-test was used to compare between two groups in non-related samples. For non-parametric data; Mann Whitney test was used to compare between two groups in non-related samples. The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Results

Table 1 showed mean and standard deviation of color parameters and mean difference between the teeth and restorations values. Results of mean difference of L* values showed a statistically significant change in the brightness (ΔL) ($p < 0.001$). A positive mean difference in the L* parameter (3.68± 4.22) denoted that the restorations were lighter in color.

Variables	Color					
	L		a		b	
	Mean	SD	Mean	SD	Mean	SD
Tooth	75.19	4.99	-0.74	1.41	18.36	4.78
Restoration	78.86	4.19	-0.62	0.98	20.08	2.82
Mean difference	3.68	4.22	0.12	0.83	1.73	2.98
p-value	<0.001*		0.366ns		0.080ns	

Table 1. The mean, standard deviation (SD) values of of color parameters and mean difference between the teeth and restorations.
*; significant (p<0.05) ns; non-significant (p>0.05)

On the other hand, there was no statistically significant difference in the a* and b* parameters between the restorations and the natural teeth indicating a close match of the Omnichroma resin composite to with the natural tooth in these parameters.

The mean value of ΔE between tooth color and the restoration color showed that there were total color differences ranged from 2.01-8.54 (5.14±1.38).

Regarding the color matching visual scoring results, there was no statistically significant difference between Observer 1 and Observer 2 groups where (p=0.111), Table 2.

Variables	VS	
	Mean	SD
Observer 1	2.33	0.64
Observer 2	2.24	0.50
p-value	0.111ns	

Table 2. The mean, standard deviation (SD) values of VS.
ns; non-significant (p>0.05)

Observer 1 scored 6 of the restorations score 1 (mismatch/totally unacceptable); 23 of the restorations scored 2 (Poor-Match/hardly acceptable), 11 of the restorations scored 3 (Good-Match/acceptable), and only 5 of the restorations scored 4 (Close-Match/small-difference). While Observer 2 scored 6 of the restorations score 1(mismatch/totally unacceptable); 26 of the restorations scored 2 (Poor-Match/hardly acceptable), 9 of the restorations scored 3 (Good-Match/acceptable), and only 4 of the restorations scored 4 (Close-Match/small-difference). Figure 1, showed percentage of color matching visual scoring for each observer. Figures 3, 4 and 5 representative clinical cases for different color matching visual scoring.

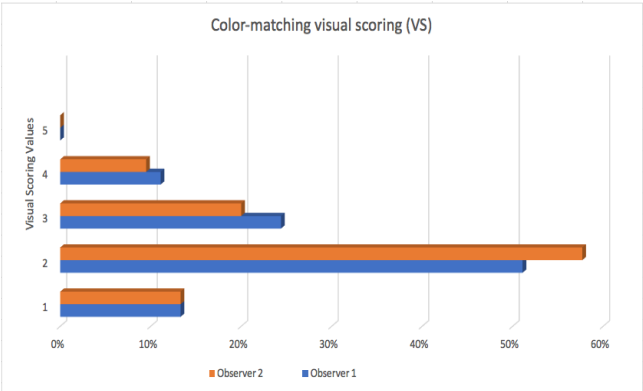

Figure 1. Bar chart representing color matching visual scoring.

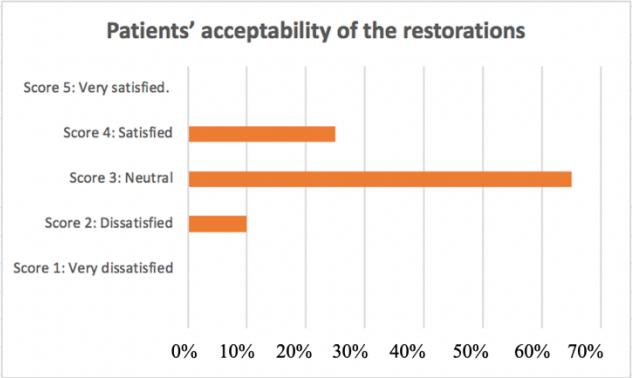

Figure 2. Bar chart representing percentage of patients' acceptability scoring.

Figure 3. Showed representative class III in upper lateral scored 4 (Close-Match/small-difference).

Figure 4. Showed representative class V in lower canine scored 3 (Good-Match/ acceptable).

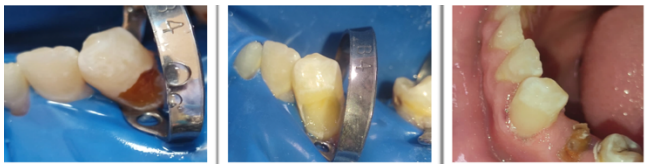

Figure 5. Showed representative class V in lower canine scored 1 (mismatch/totally unacceptable).

Regarding patients' acceptability of the restoration color results revealed that 65% of the patients showed neutral acceptability (score 3), 25% of the patients showed satisfied acceptability (score 4) and 10% of the patients showed dissatisfied acceptability (score 2).

Discussion

Aesthetic dental restorations are under continuous development aiming to gain natural-looking appearance. One of the recently introduced dental resin composites in the market is Omnichroma® which enjoys a unique merit of a smart chromatic technology to control its optical properties. According to the manufacturer, the color properties of Omnichroma® was based on structural color/s, which occurs when dissimilar wavelengths of light are intensified or weakened by the composition of a material itself, showing colors other than what the material may really have. Omnichroma had no pigments, so its color properties is related only to the physical properties of light due to absence of pigments [19, 20], on the contrary to traditional resin composites that gain their color chemically by adding dyes into the material [20, 21]. The manufacturer utilized only single-sized spherical filler particles (260nm) as a filler material [20], to enable the resin composite to respond to the light waves at an assumed frequency by thoroughly reflecting a particular wavelength inside the tooth color space[22].

In the current study, a digital spectrophotometer (Vita Easyshade) was employed. It is an International Commission on Illumination (CIE) L*a*b* color system [7, 23]. This system has the advantage of its visually uniform coverage of the color space. Moreover, the accuracy and precision of the Easyshade had been proven in both in vitro standardized condition and the clinical conditions [24, 25].

In the current study, the color assessment of both the tooth structure and the restoration were done after removing the rubber dam and rehydration of the teeth for 60 min. This was done as clinically recommended by Hafez and Abou-Steit [14], in order to avoid the dehydration effect that leads to an increase in the enamel opacity. A new interface is created due to tooth dehydration, where there was a substitute of water around the enamel prisms with air. Thus, the reflective indices of enamel undergo great alteration with superior scattering at the dehydrated enamel- air interface compared to enamel-water interface. Therefore, the lower translucency of dehydrated enamel resulted in more reflection so masking the dentin yellow shade, that could be decoded as a light appearance of the dehydrated tooth [14, 26, 27].

The success of resin composite esthetic restorations depends greatly on the color matching between the restoration and the tooth structure [28]. Results of the current study revealed a significant differences in color matching between the teeth and the tested single shade universal composite, rejecting the null hypothesis.

Two main thresholds were utilized for evaluating differences in color: perceptibility threshold (PT) and acceptability threshold (AT) [29, 30]. 50:50 % perceptibility threshold of difference in colour means that 50 % of observers could detect color differences while the other 50 % of observers could not observe a color difference between the compared objects under controlled conditions. In dentistry a perfect colour match is a difference in colour at or below the 50:50 % perceptibility threshold. On the other hand, 50:50 % acceptability threshold of colour difference means that there is a color difference between two object under controlled conditions that is acceptable to 50% of the observers, while the other 50% of the observers recommend replacing or correcting the restoration as the color differences detected is not acceptable to them. An acceptable colour match in dentistry is a colour difference at or below the 50:50 % acceptability threshold.

The scientific spectrophotometer analyzed the parameters L, a, and b for each tooth and restoration, from which the values of ΔE, ΔL, Δa and Δb resulted. The total color difference (ΔE) was assessed for acceptability and perceptibility. The perceptible value for ΔE in a 50%:50% threshold was described to be 1 (ΔE <1). While the acceptance value for the color difference was set to be above 3.3 (ΔE <3.3) [2, 3, 31]. Though, difference in color which is larger than a ΔE value of 3.3 might still be acceptable clinically, dependent on the extent of translucency and polychromaticity of the teeth next to the restoration [32]. In the current study the ΔE mean value was (5.14±1.38) which was above both the perceptibility threshold of (ΔE >1) and the acceptability threshold (ΔE>3.3), which is not clinically acceptable. This was supported by the visual color match scoring the indicated that a color differences were perceived by the two observers in all the cases, Figure 1 (0% score 5: Exact-Match/no-color-difference). Moreover, the lower acceptability rate for the difference in the color between the restorations and the teeth was supported by the high percentage of cases (26% and 23% for observer 1 and 2 respectively) scored 2 (Poor-Match/hardly acceptable), and 6% of the cases scored 1 (mismatch/totally unacceptable) with both observers. Indicating that more than 70% of the cases were clinically unacceptable.

In the current study the only statistically significant difference between the restorations and the teeth was found in the the L* parameter, indicating that the restorations did not have the same lightness value as the teeth. This could be related to the translucency parameter (TP) of the omnichroma resin composite. The translucency is directly correlated to the lightness (value) of the material [16, 33]. The value color element was found to have a higher significance than chroma and hue, as the human eye is hypersensitive to black and white more than the other parameters. Moreover, a significance of this property was confirmed by Perez et al, [30] who found a higher 50:50% acceptability values for lightness than hue and chroma.

In the current study, patient acceptability was evaluated as patient satisfaction is considered an important part in the success of dental treatment. Likert-type scale had been used as it is a simple tool with satisfactory reliability and validity [18, 34].

Patients'acceptability evaluation, revealed that 65% of the patients showed neutral acceptability (score 3), 25% of the patients showed satisfied acceptability (score 4), which was contradicting the color match visual scoring done with the PhD students and the spectrophotometer measurements.

This might be related to that patients lack of training and clinical knowledge that mandates color matching of materials with natural teeth, except that they were tooth colored. In contract to the PhD students who performed the color match visual scoring, who had this level of training and experience. This was supported by a recent study by Ragain and Johnston [2], who found that the patients group had the highest statistically significant mean 50:50 Δ*E* replacement point than the dentists, dental auxiliaries and hygienists groups. The 50:50 Δ*E* replacement point was defined as color difference at which the observer had an equal probability of either rejecting or accepting the restoration [2].

Conclusions

Under the limitations of the current clinical study, it could be concluded that:

- Omnichroma® single shade universal resin composite showed showed poor clinical color matching values in class III and V restorations in anterior teeth and were unacceptable to the PhD dental students.

- There was a high satisfaction level among the patients for the single shade universal resin composite

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Declaration of Interest

The authors reported no conflict of interest

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