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EVALUATION OF COLOR MATCHING ABILITY OF A SINGLE SHADED RESIN COMPOSITE VERSUS A SINGLE TRANSLUCENCY RESIN COMPOSITE WITH DIFFERENT TEETH SHADES

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Color, Composite, Shade.

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ABSTRACT

Aim: This in-vitro study digitally evaluates the color matching ability of a single-shaded resin composite and a single-translucency resin composite system placed in teeth with three different teeth shades at two different cavity depths, and to compare both of them to a multi-shaded resin composite system. **Methods:** 90 extracted sound teeth were selected and their shade was recorded. Teeth were divided according to their shade into three groups (S_1,S_2 and S_3). In each group, Class V cavities were prepared at 0.5 mm depth (Subgroup D_1) for half of the teeth, while cavities in the other half were adjusted at 1.5 mm depth (Subgroup D_2). Each subgroup was further divided into three classes according to the restorative material placed in the prepared cavities (M_1, M_2 and M_3). Shade was recorded after placement and ΔE was calculated. **Results:** Single-shaded resin composite (M_1) recorded the significant lowest ΔE values wih S_1 followed by S_2 and S_3 respectively ($P \leq 0.05$). Multi-shaded resin composite (M_3), generally showed the best results with the three teeth shades compared to the other two materials. No significant differences were found at both cavity depths for all groups ($P \leq 0.05$). **Conclusions:** The single-shaded resin composite showed more acceptable color matching at lighter teeth shades than at darker teeth shades. Multi-shaded resin composite showed superior color matching ability at the three different teeth shades. The selected cavity depths had no siginificant effect on the color matching ability of the different resin composite materials used.

INTRODUCTION

Resin composites are commonly used in dentistry for restorative treatments, esthetic treatments and modification of tooth color and contour [(1)]. Since their introduction approximately 50 years ago, these resins have undergone gradual development and modifications in order to enhance their properties as an esthetic restorative material. These modifications included modification of the composite resin filler types, decreased polymerization shrinkage, advanced enamel and dentin adhesive systems, increased strength and longevity, and better esthetic properties[(2)]. A nano-hybrid-composite with prepolymerized fillers with five ”cloud shades“ that cover the full VITA color range of natural teeth. Cloud shades cover more than one VITA shade, because the shade of these universal restorations is influenced by the color of the surrounding tooth structure. This phenomenon is called *chameleon effect* which is the ability to match the color of the surrounding teeth[(3)]. Recently a new resin-based composite (Omnichroma®) has been developed, formulated on a ”Wide Color Matching“ concept, creating shades that can cover a wide range of natural teeth colors to reduce the time of shade taking and reduce the amount of composite shades needed. The range of colors for natural teeth is quite limited and distributed in the narrow range of red to yellow from A1 to D4, with varying degrees of lightness, darkness, and saturation. Omnichroma® is a composite that achieves wide color matching by generating red-to-yellow structural color equivalent to that of natural teeth in an additive color mixing system[(4)]. Thus, it was found interesting to evaluate the color matching ability of these recent esthetic materials compared to traditional multiple shade resin composite material.

MATERIALS AND METHODS

Sample size calculation

Two way analysis of variance (ANOVA) was proposed. A total calculated sample size of 90 samples was sufficient to detect the effect size of 0.55 according to Cohen (1988) (73), a power (1-β=0.80) of 80% at a significance probability level of $p<0.05$ partial eta squared of 0.21. According to sample size calculations each subgroup of tooth shade (S_1,S_2, S_3), cavity depth (D_1, D_2), and restorative materials (M_1, M_2 and M_3) would be represented by a minimum of 5 samples with a total sample size of 90 samples. The sample size was calculated according to G*Power software version 3.1.9.3.

Study design

This study was carried out on 90 sound non-carious anterior teeth obtained from patients undergoing extraction in the clinic of Oral Surgery Department due to periodontal diseases or in preparation to receive a full denture. Immediately after extraction, teeth were thoroughly washed under running water to remove blood and mucous, scaled to remove calculus and remnants of periodontal ligament and then polished with fine pumice and soft rubber cups at conventional speed. The teeth were examined for freedom of cracks using a magnifying lens. All the teeth exhibiting any signs of caries, micro-cracks or any other defective structures were discarded. The teeth were then stored in distilled water having 0.5% chloramine-T antiseptic solution at room temperature until being utilized [(5)].

The teeth were divided according to their shade (S) into three groups with 30 teeth in each group; group (S_1) for teeth with shade A2, group (S_2) for teeth with shade A3 and group (S_3) for teeth with shade A3.5. Each group was divided into two subgroups with 15 teeth in each class according to the cavity depth (D) of the prepared cavity; class (D_1) for teeth prepared at cavity depth of 0.5 mm and class (D_2) for teeth prepared at cavity depth of 1.5 mm. Each subgroup was then divided randomly into three classes with 5 teeth in each class according to the restorative material (M) that would be placed in the prepared cavity; class (M_1) for teeth that would be restored with Omnichroma® (Tokuyama Dental America Inc.), class (M_2) for teeth that would be restored with Ceram.X® SphereTEC™ one (Dentsply), and class (M_3) for teeth that would be restored with Filtek Z250™ XT (3M ESPE). (n = 5).

Pre-operative procedures

After all teeth were cleaned and polished, the shade of each tooth was recorded using a spectrophotometer (VITA Easyshade® V, VITA Zahnfabrik, Bad Sackingen, Germany) before beginning of cavity preparation and teeth were assigned to the three main groups of the study according to tooth shade S_1, S_2 and S_3.

Operative procedures and restoration

Teeth were fixed in dental stone molds to display only the coronal portion of the teeth and to allow for more ease of handling. Circular Class V cavities with 3 mm diameter (Figure 1a) were prepared 0.5 mm coronal to the cervical line on the buccal surface of all selected teeth using No.56 carbide fissure bur (Komet, Germany) in a high speed hand piece with a copious water spray [(6)]. New burs were used after every five cavities in order to ensure high cutting efficiency [(7)]. Incisal enamel margins were finally beveled with a short bevel using a diamond fissure bur (FG 110-014, Dentsply Sirona) [(8)].

In each S group (30 teeth) , 15 cavities were adjusted to have a depth of 0.5 mm (D_1) while the other 15 cavities were prepared to have depth of 1.5 mm (D_2). The depth of cavities was millimetrically standardized using a periodontal probe[(9)]. Every 15 cavities of the same depth were randomly divided into 3 subgroups (n=5) according to the type of resin composite restoration that will be placed in each of them (M_1,M_2,M_3).

Each cavity was etched with 37% phosphoric acid etching gel for 20 seconds and was then rinsed with water spray for 30 seconds to ensure complete removal of the etching gel byproducts [(10)]. After rinsing and blotting excess moisture from the prepared cavities using a cotton pellet, a universal dentin bonding agent (Tetric® N-Bond Universal, Ivoclar Vivadent) was applied to the cavities with a micro brush according to manufacturer's instructions. A gentle air flow for 2-5 seconds was applied and the bonding agent was then light cured for 20 seconds using blue-phase light curing unit with an output power of 800mW/cm^2 power density (Bluephase C8, Ivoclar Vivadent). All light curing procedures were performed from the labial direction

After etching, rinsing, drying and bonding, single shade Omnichroma® was placed in subgroup M_1, the specific cloud shade of Ceram.X® SphereTEC™ one was selected for restoration of the cavities in subgroup M_2, while the specific shade of Filtek Z250™ XT was selected for restoration of the cavities in subgroup M_3. In all cavities, resin composite was placed incrementally with increments thickness of no more than 0.5 mm. No matricing was performed. All light curing procedures were performed from a labial direction. The curing distance was standardized through applying the tip of the curing unit on the labial surface of the teeth. The restorations were then finished with a sequential protocol using fine grit diamond burs and polishing discs (Soflex; 3M ESPE, St. Paul, MN, USA) (Figure 1b)

Evaluation of shade matching

The shade of each restoration was recorded using the spectrophotometer (VITA Easyshade® V, VITA Zahnfabrik, Bad Sackingen, Germany) immediately after placement (Figure 1c) and the shade difference between the restoration and that of the tooth (ΔE) was calculated using the equation:

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

Where L^* represents the lightness of the color, a^* represents the redness-greenness of the color while b^* represents the yellowness-blueness of the color.

Statistical analysis

All the obtained data were then recorded, tabulated, checked for normality and statistically analyzed using IBM SPSS for Windows version 20.0 software (SPSS, Chicago, IL, USA).

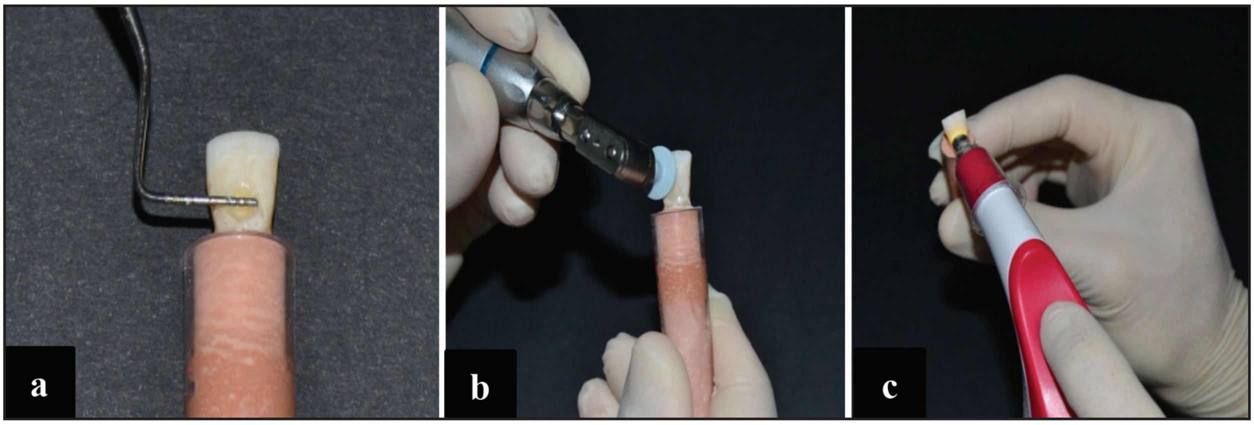

Fig. (1) (a) Checking the dimensions of the prepared cavity using a periodontal probe. (b) Polishing of the restorations. (c) Recording the shade of the restorations with VITA Easyshade® V to compare it with that of the teeth.

RESULTS

Data presented in Table (1) shows the interaction between the three teeth shades; A2 (S_1), A3 (S_2) and A3.5 (S_3) with the three restorative materials; Omnichroma® (M_1), Ceram.X® SphereTEC™ one (M_2) and Filtek™ Z250 XT (M_3) at the two different cavity depths; 0.5mm (D_1) and 1.5mm (D_2).

Regarding the interaction of each restorative material with three different teeth shades, data showed that Omnichroma® (M_1) recorded the lowest ΔE values wih S_1 followed by S_2 and S_3 respectively. The differences of values between the three shades were statistically significant. With Ceram.X® SphereTEC™ one (M_2), lowest ΔE values were recorded with S_1 followed by S_2 and S_3. Statistically significant difference was recorded between the values of M_2 at S_1, S_2 and S_3. Filtek™ Z250 XT (M_3), generally showed the best results with the three shades compared to the other two materials. The ΔE values with the three shades were nearly the same with no statistically significant differences.

Regarding the interaction of the three restorative materials within each shade, data of Table (1) revealed that in S_1, ΔE values of Omnichroma® (M_1) and Filtek™ Z250 XT (M_3) were significantly lower than those of Ceram.X® SphereTEC™ one (M_2). In S_2, ΔE values of Filtek™ Z250 XT (M_3) were significantly lower than Ceram.X® SphereTEC™ one (M_2) and Omnichroma® (M_1). Statistical significance was observed between the values of the three materials in S_2. In S_3, the same trend as in S_2 was observed where the difference between ΔE values of the three restorative materials was statistically significant.

Three-way ANOVA ($P \leq 0.05$) revealed generally that Filtek™ Z250 XT (M_3) recorded lower ΔE values compared to the other two restorative materials with the three shades at both depths. Data also shows that Omnichroma® (M_1) with shade A2 (S_1) recorded low ΔE values at D_1 and D_2 (3.27 and 3.49 respectively) which were very close to those of Filtek™ Z250 XT (M_3). ΔE values of Omnichroma® increased with S_2 at D_1 and D_2 (5.34 and 6.04 respectively) and recorded the highest ΔE values with S_3 at D_1 and D_2 (8.04 and 8.78 respectively). Ceram.X® SphereTEC™ one (M_2) recorded intermediate ΔE values between Omnichroma® (M_1) and Filtek™ Z250 XT (M_3) at all shades with both depths except for M_2 with S_1 where ΔE values were higher than that of both other materials.

The results showed no significant difference between ΔE values at D_1 and D_2 for all restorative materials at the three different shades.

Table (1) *ΔE values of the study and interaction between the variables.*

Shade (S)	Material (M)	Depth (D)		Mean (μ)	Standard deviation (σ)
		D_1	D_2		
S_1	M_1	3.27 [e]	3.49 [e]	3.31	0.45
	M_2	4.42 [d]	4.75 [cd]	4.59	0.68
	M_3	3.39 [e]	3.30 [e]	3.35	0.46
S_2	M_1	5.34 [c]	6.04 [bc]	5.74	0.81
	M_2	4.99 [cd]	5.33 [c]	5.16	0.75
	M_3	3.52 [e]	3.18 [e]	3.35	0.56
S_3	M_1	8.04 [a]	8.78 [a]	8.41	0.77
	M_2	6.31 [b]	6.65 [b]	6.48	0.54
	M_3	3.44 [e]	3.33 [e]	3.39	0.41
		L.S.D (0.05) = 0.773			

ΔE	3-way ANOVA		
Source	Df	F-ratio	Significance
Corrected Model	17	40.32	<0.001
Depth (D)	1	3.21	0.078
Shade (S)	2	110.54	<0.001
Material (M)	2	138.71	<0.001
Depth x Shade (D x S)	2	0.26	0.774
Depth x Material (D x M)	2	2.75	0.071
Shade x Material (S x M)	4	43.94	<0.001
Depth x Shade x Material (D x S x M)	4	0	0.757

DISCUSSION

This study was performed to assess and compare the differences between different tooth shade groups (S_1, S_2 and S_3) and different restorative materials (M_1, M_2 and M_3) at two different cavity depths (D_1 and D_2). This design was chosen to assess the effect of cavity depth on color matching of different restortions at standardized cavity depths which was not applicable in the in vivo studies where cavity depths are controlled by the extent of carious lesions. New burs were used after every five cavities in order to ensure high cutting efficiency. This methodology was recommended by **Plotino *et* al.** [(7)].

In the current study, three teeth shades were selected for each material to investigate the effect of teeth shade (light versus dark shades) on the color matching ability of each restorative material. The three selected shades; A2, A3 and A3.5 were used since these were demonstrated by **de Abreu *et* al.** to be of the most frequent VITA shades for anterior teeth [(11)].

It has been reported by **Mourouzis *et* al.** that the color of the teeth is mainly determined by the dentin and not the enamel, with the latter having a minor influence on the teeth color but it's main influence on the color perception is in terms of lightness [(12)]. In the current study, to overcome this problem, class V cavities were chosen to be prepared in the tooth specimens since the minimal enamel thickness in this area allowed the restoration shade to be affected by the dentin color. This was also recommended by **Riad *et* al.** [(13)].

Determination of shade procedure can be done by visual or instrumental color determination. In the present study, shade reproduction of all restorations was recorded with Vita Easyshade® V spectrophotometer device to exclude human variables in detecting shade differences. The use of VITA easyshade V spectrophotometer to evaluate color change was in accordance with **Dozic *et* al.** who found VITA Easyshade to be the most precise among five other commercially available devices, both in vitro (VITA shade tabs) and in vivo and they reported that the device provided reliability and accuracy [(14)].

Although there are several formulae for color difference calculation, the most commonly used system in dental research is obtained from the CIELab system. **Khashayar *et* al.** searched the dental literature to provide data on acceptability and perceptibility thresholds and referred to the ΔE value of 3.7 as an acceptable threshold. This value has been used as a benchmark reference for several investigators [(15)].

The results of the present study showed that the best color matching was recorded with the multi-shaded resin composite at all tested shades indicating the best color matching with natural teeth. In the multi-shade resin composite used in this study, the manufacturer improved the filler system with the addition of nanoparticles and nanoclusters which are bound in the resin matrix. The result is an optimized nanohybrid composite with a unique combination of fillers that made the system easy to be polished with good polish retention, providing predictable esthetic results.

The single-shaded resin composite restorations showed good color matching with the lighter tooth shade S_1 (A2) while color matching ability decreased as the tooth shade became darker (S_2, S_3). The difference of color matching with the three tooth shades used in the current study was statistically significant. The superior color matching of the single-shade resin composite with light shades might be attributed to its high translucency reflecting the shade of the surrounding walls. This explanation was in agreement with **Abdelraouf and Habib**[(16)]. **Paravina *et* al.** also reported that the blending effect increased with increasing the translucency [(17)]. On the other hand, the decreased color matching ability with the darker shades may be attributed to the decreased amount of light that is reflected from the darker-shaded teeth through the restoration which may have affected the way by which the material shifts towards the tooth shade resulting in incomplete ability of the restoration to blend with the surrounding tooth structures.

The color matching of the group-shaded resin composite with all tooth shades used was significantly inferior to that of the multi-shaded resin composite. This may be attributable to the use of "cloud shades" which have to cover three to four shades resulting in no exact matching to any of them [(18)]. Moreover, the group-shaded resin composite used in the study is described by the manufacturer to have a single moderate translucency. This may attribute to their poor blending effect as **Paravina *et* al.** reported that the blending effect increases with increasing the translucency of the resin composite[17]. The color matching ability of group-shaded resin composite was inferior to that of the single-shade resin composite at shade S_1 (A2) while it was superior to that of the single shade resin composite at shades S_2 (A3) and S_3 (A3.5).

The results of the current study showed no statistical significant difference in color matching between D_1 (0.5 mm cavity depth) and D_2 (1.5 mm cavity depth) for all the three used restorative materials with the three different shades. It has been stated by **Paravina et al,** that increasing cavity size might decrease the blending effect of resin composite restorations [19]. However, in the current study the color matching results showed similar trends at both depths. One possible reason behind this finding might be the relatively shallow depths selected in this study where the depth selection was restricted by the limited enamel and dentin thickness available for cavity preparations at the cervical part of anterior teeth in class V cavities.

CONCLUSIONS

Within the limitations of this study it can be concluded that:

The single-shaded resin composite showed more acceptable color matching at lighter teeth shades than at darker teeth shades.

Color matching of group-shaded resin composite is superior to that of single-shaded resin composite at darker shades.

Multi-shaded resin composite showed superior color matching ability at the three different teeth shades.

The selected cavity depths had no siginificant effect on the color matching ability of the different resin composite materials used.

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