SPECTROPHOTOMETRIC ANALYSIS OF DISCOLORED ANTERIOR TEETH RESTORED WITH PREFAPRICATED COMPOSITE RESIN VENEERS

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ABSTRACT

INTRODUCTION: Veneers are considered the least invasive most reliable solution for treatment of discolored anterior teeth. Edelweiss system is a polymerized, prefabricated, laser-machined, radiopaque, highly-filled nano-hybrid composite enamel shells with a highly glossy inorganic surface. They have a facial anatomical pattern in the shape of a thin composite shell bonded to labial surface of anterior teeth with composite resin, which allows for easy direct veneering of single and multiple anterior teeth.

OBJECTIVES Spectrophotometric analysis of discolored anterior teeth restored with Edelweiss veneer system bonded with different shades of composite resin.

MATERIALS AND METHODS: Twenty Edelweiss veneers bonded with different shades of composite resin (A2, opaque white and translucent shades) to dies of different shades. Specimens were divided into four groups, each group consists of five specimens, according to the shade of the bonding composite resin used and the shade of the dies. Spectrophotometer was used to evaluate the effect of using different shades of the bonding composite on the final shade of the restoration. Also, to assess the light reflection, transmission and absorption of the Edelweiss Veneer System.

RESULTS: The L*a*b* coordinates values of the Edelweiss Veneer Systems were affected by the shade of bonding composite ($P<0.05$). The use of an opaque bonding composite resulted in an increase of the color coordinates a*, b*, L*, producing the greatest effect on color change, light transmission and light reflection ($P<0.05$). Light absorption values of the specimens were not affected by the shade of the bonding composite.

CONCLUSIONS: On using Edelweiss veneer system, the greatest color shifts and change in light transmission and light reflection were obtained when using opaque shade composite for bonding of the veneers to the substrates. While light absorption was of a non-significant value among the groups.

KEYWORDS: Edelweiss veneer, ready-made veneer, spectrophotometer, discolored teeth.

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INTRODUCTION

One of the most challenging cases that presents to the dental office is the single, discolored central incisor. The dentist has to make the difficult decision on how to effectively and esthetically restore the tooth back to its natural color and original form. There are many different restorative techniques and materials to choose from (1).

When deciding on what material to use as a restoration, the pros and cons of porcelain and composite should first be reviewed. Porcelain restorations are stronger than composite. But, they are also more expensive. Porcelain may require more tooth preparation, and may be more difficult to match to a single central incisor. Conversely, composite resin is not quite as strong as porcelain, requires more clinical skills, and, in some cases, may not have the longevity of porcelain (2).

The idea of veneering of anterior teeth was presented in 1937 by Dr. Pincus. It became more popular in the mid-seventies, using three different approaches: direct bonding using resin composites, prefabricated composite veneers and indirect custom-made porcelain veneers (3,4).

The use of pre-fabricated composite veneer (Mastique®, Caulk) was then explored about 35 years ago, using a methyl-methacrylate matrix and large glass fillers, such as used in resin composites (5), however with limited success due to technological limitations and poor surface qualities. The rapid loss of surface gloss and surface degradation of prefabricated resin veneers linked to some interfacial defects led the system to be soon abandoned and definitely replaced by porcelain veneers (6).

The advantages of a minimal- or no-preparation porcelain veneer are obvious; There is no harm to the pulp and it will result in no postoperative sensitivity. With the enamel intact, the bond strength is the best it can possibly be. There is no question that the strength of dentin bonding agents is much higher than it ever has ever been, however there is still no comparison to resin bonding to enamel. Enamel bonding has always been more predictable, stronger, and more long-lasting (7).

Minimal preparation may be necessary, depending on a number of factors. These include but are not limited to teeth that are severely rotated, labially inclined, and severely discoloured. Minimal preparation is reduction of the enamel, usually to a depth not exceeding 0.5 mm. Every effort is made to maintain the integrity of the enamel and not expose the underlying dentin (8).

With a no-preparation porcelain veneer technique, there is no worry about managing the gingiva as veneers are supragingival. Care has to be applied not to over contour the cervical region of the tooth, which could create a trap for plaque and cause a detrimental tissue response. Imagine the ease with which an impression is taken. Another big advantage to this technique is that there is no temporization. Indeed, the hardest temporary to make and maintain is the porcelain veneer temporary. Then, once it is made, a decision has to be made on how it is going to stay on the teeth, either with spot bonding or by locking into undercuts. There is no need to temporise since the patient's appearance has been barely changed (9).

The final color of a veneer restoration could be influenced by the color, translucency, and thickness of the underlying resin luting agent (10-12). Resin luting cements, considered as active-type cements, have increasing applications in the cementation of fixed prosthesis, since they exhibit enhanced mechanical, physical, and adhesive properties compared with those of other conventional luting agents. Furthermore, they provide adequate stability and increased fracture resistance of overlying restorations, together with an optimal esthetic result. Presently, resin luting cements are supplied in different shades to enhance final color match and to allow clinicians to select the proper cement shade for veneers to obtain desirable esthetics. However, the impact of cement shades on the final color of veneer restorations remains controversial (13,14).

The higher the translucency of the resin cement, the more natural the appearance, whereas opaque cement will mask the tooth and make it more monochromatic. Opaque cements are more commonly used to block the darkness of severely discolored teeth (14,15).

Edelweiss veneer system is a polymerized, prefabricated, laser-machined, radiopaque, highly-filled nano-hybrid composite enamel shells with a highly glossy inorganic surface. They have a facial anatomical pattern in the shape of a thin composite shell bonded to labial surface of anterior teeth with composite resin, which allows for easy direct veneering of single and multiple anterior teeth (16).

This study was conducted to evaluate the change of color, light transmission, reflection, and absorption of Edelweiss veneer restoring discolored teeth using different shades of bonding composite.

MATERIALS AND METHOD

Preparation of the master die

A student teaching model with interchangeable hard resin teeth was used and the upper right central incisor (#ll) was selectively prepared to be adjusted to fit to Edelweiss veneer, medium size, using rounded-end tapered diamond. After that the preparation was polished, and finished with cups and discs.

Production of the study specimens

The model of the prepared tooth duplicated using silicon duplicating material, which was then poured with hard stone type IV.

A thermoplastic transparent sheet (0.06) inch thick was adapted on the stone prepared die under vacuum pressure using vacuum forming machine to form a transparent template for the prepared tooth. Twenty transparent templates were constructed.

The transparent template was used for fabrication of five composite substrates with A2 shade and for resembling discolored teeth; fifteen discolored substrates were built up with different composite shades: cervical third with A5 resin composite, the middle third with A3.5 resin composite, and the incisal third with A2 resin composite.

Bonding of laminate veneers:

Three shades of composite resin were used in this study to test the influence of the composite resin shade on the final shade of the veneers and to investigate how a dentist can mask the underlying tooth color using different composite resin shades. Bonding was done according to manufacturer's instructions:

1. Ultra-Etch was applied to the fitting surface of the veneer with the micro tip for 5 seconds, rinsed and dried to clean the surface.
2. Peak Universal Bond was coated to the veneer surface with a brush. Light cure was applied for 10 seconds.
3. One cm of Amelogen Plus composite resin of pre-selected shade was expressed from its tube and placed into the internal surface of the veneer. The veneer was adapted on its corresponding resin die with light finger pressure till no excess was coming out.
4. Excess composite at the cervical margin was removed with an explorer.
5. Marginal adaptation was checked using 3.5X magnifying loups.
6. Light cure was applied for 20 seconds to the labial and the palatal surfaces.

GROUPING

The specimens were grouped into four groups according to substrate shade and composite resin shade used to bond the veneer to the substrate (Fig.1,2), 5 specimens per each.

Group I: 5 Laminate veneers bonded with A2 shade composite resin to the substrates of A2 shade.

Group II: 5 Laminate veneers bonded with translucent shade composite resin to the discolored substrates.

Group III: 5 Laminate veneers bonded with opaque shade composite resin to the discolored substrates.

Group IV: 5 Laminate veneers bonded with A2 shade composite resin to the discolored substrates.

Figure 1: Resin dies. a. Discolored die. b. A2 shade die

Figure 2: Veneers bonded to resin dies a. Group I. b. Group II. c. Group III. d. Group IV.

Testing of the specimens

The spectrophotometric analysis of the specimens was done using a reflectance spectrophotometer.

A computer color matching system (UV. Shimadzy 3101 PC) was used for the spectrophotometric assessment of the specimens (Fig.3). Measurements was done in Photometry Department; National Institute of Standards, Giza, Egypt.

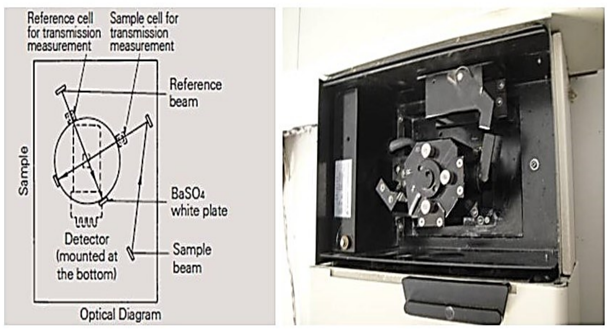

Figure 3: Photometric unit

Shade evaluation

Each Group was subjected to three measurements as follows:

- First measurement of Composite resin dies.
- Second measurement of Composite resin dies with veneer seated on it.
- Third measurement of Composite resin dies with veneer bonded to it.

To standardize all the specimens' measurements, they were placed on the device holder at the same position each time so that the hole of the holder was against the center of the specimen.

For Group I:
First measurement GI_1: Composite resin dies with A2 shade.
Second measurement GI_2: Veneers seated on composite resin dies of A2 shade.
Third measurement GI_3: Veneers bonded to composite resin dies of A2 shade with A2 shade composite resin.

For Group II:
First measurement GII_1: Composite resin discolored dies.
Second measurement GII_2: Veneers seated on discolored composite resin dies.
Third measurement GII_3: Veneers bonded to discolored composite resin dies with translucent shade composite resin.

For Group III:
First measurement $GIII_1$: Composite resin discolored dies.
Second measurement $GIII_2$: Veneers seated on discolored composite resin dies.
Third measurement $GIII_3$: Veneers bonded to discolored composite resin dies with opaque white shade composite resin.

For Group IV:
First measurement GIV_1**:**Composite resin discolored dies.
Second measurement GIV_2**:** Veneers seated on discolored composite resin dies.
Third measurement GIV_3**:** Veneers bonded to discolored composite resin dies with A2 shade composite resin.

Color Difference Measurement (ΔE)
It's based on the differences in CIE $L^*a^*b^*$ parameters between different groups as follow:

$$\Delta E= [(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$$

Where
$L^*a^*b^*$ values were obtained from the spectrophotometer.
ΔE_1 is color difference between first and second measurement.
ΔE_2 is color difference between second and third measurement.
ΔE_3 is color difference between first and third measurement.

Reflection Parameter Measurement (R)
Reflection is the change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated.
R value was obtained from the spectrophotometer.

Transmission Parameter Measurement (T)
T = 100 - R

Absorption Parameter Measurement (A)
The absorption of light occurs when a ray of light strikes a surface. The energy from the light is transferred to the surface material. An absorbing surface prevents reflection or diffusion of light striking on the surface.
A = log (1/T)

STATISTICAL ANALYSIS

The data was processed, and analyzed using T-test. The study included descriptive and analytical data. A P-value of less than (0.05) was considered statistically significant.

RESULTS

Seating the veneers on the resin dies without bonding composite resulted in a clinical non-significant color change for all the groups. While bonding of the veneers to the resin dies resulted in an observed color shift with the highest ΔE value related to group III where opaque bonding composite was used, followed by group IV where A2 shade bonding composite was used, then group II where translucent shade bonding composite was used. The values of ΔE are presented in (Table 1) (Fig.4).

Table 1: Comparison between the different groups according to color difference (ΔE).

	ΔE_1		ΔE_2		ΔE_3		P1	P2	P3
	Mean	SD	Mean	SD	Mean	SD			
Group I	2.7	0.7	5.1	2.3	5.4	1.9	0.04*	0.78	0.01*
Group II	6.6	0.1	4.7	0.5	8.0	0.1	0.04*	0.001*	0.03*
Group III	6.6	0.1	15.1	0.2	14.4	0.2	0.01*	0.82	0.02*
Group IV	6.6	0.1	6.8	0.4	7.1	0.3	0.54	0.52	0.49
P4	0.03*		0.03*		0.02*				

P1: Adjusted P value of t-test for ΔE_1& ΔE_2
P2: Adjusted P value of t-test for ΔE_2& ΔE_3
P3: Adjusted P value of t-test for ΔE_1& ΔE_3
P4: Adjusted P value of t-test for group I, II, II and IV
* $P < 0.05$ (significant)
*: Significantly different

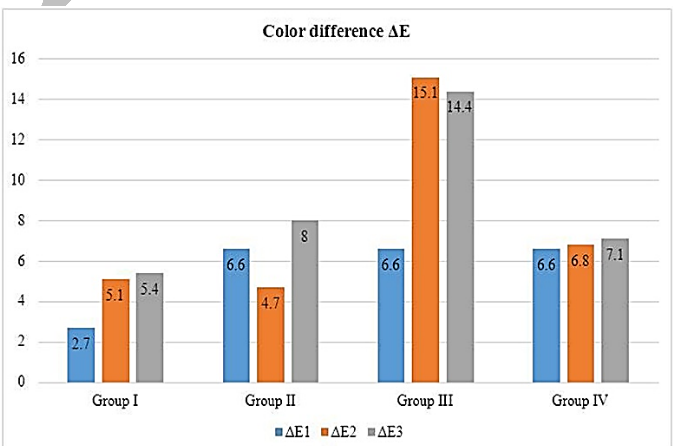

Figure 4: Comparison between the different groups according to color difference (ΔE).

Light reflection and light transmission of the specimens was affected by the shade of the bonding composite. The highest significant value of light reflection was obtained in group III. However, the lowest significant value of light transmission was obtained in group III. Also the greatest shift of light reflection and light transmission was found in group III. The values of light reflection and light transmission are presented in (Table 2) (Fig.5).

Table 2: Comparison between the different groups according to light reflection (R) and light transmission (T).

		Group				P3
		Group I	Group II	Group III	Group IV	
		R/T	R/T	R/T	R/T	
Dies only	Minimum	27.4/72.6	27.5/72.5	28.3/71.7	28.8/71.2	0.198
	Maximum	29.1/70.9	29.0/71	29.3/70.7	30.4/69.6	
	Mean	28.0/72.0	28.4/71.6	28.9/71.1	29.5/70.5	
	SD	0.9	0.8	0.5	0.8	
Veneer seated on resin dies (no bonding composite)	Minimum	26.7/73.3	26.0/74.0	26.5/73.5	27.3/72.7	0.231
	Maximum	28.3/71.7	27.2/72.8	27.9/72.1	27.8/72.2	
	Mean	27.6/72.4	26.5/73.5	27.1/72.9	27.5/72.5	
	SD	0.8	0.6	0.7	0.3	
Veneers bonded to resin dies with bonding composite	Minimum	33.5/66.5	31.4/68.6	44.6/55.4	35.0/65.0	0.001*
	Maximum	35.5/64.5	32.9/67.1	46.6/53.4	36.0/64.0	
	Mean	34.4/65.5	32.1d/67.9 d	45.8d/54.2 d	35.4/64.6	
	SD	1.0	0.7	1.1	0.5	
P1		0.125	0.175	0.216	0.175	
P2		0.038*	0.053	0.001*	0.028*	

P1: Adjusted P value of t-test for dies only group & veneers seated on resin dies (no bonding composite) group
P2: Adjusted P value of t-test for dies only group & veneers bonded to resin dies group
P3: Adjusted P value of t-test for group I, II, II and IV
* P < 0.05 (significant)
*: Significantly different group(s)

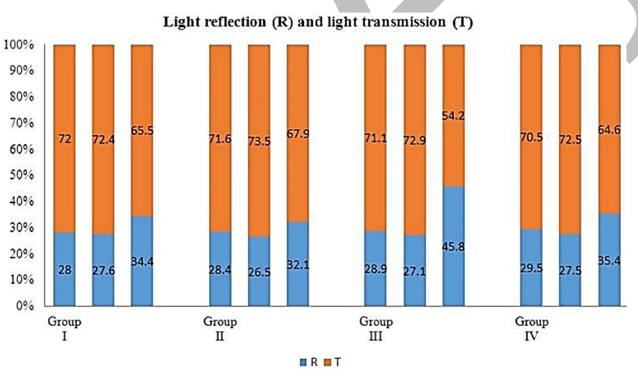

Figure 5: Comparison between the different groups according to light reflection (R) and light transmission (T).

Light absorption of the specimens was not affected by the shade of the bonding composite. The values of light absorption were not significantly different between different measurements among the four groups. The values of light absorption are presented in (Table 3) (Fig.6).

DISCUSSION

The color difference values (ΔE) have been demonstrated by the following studies which demonstrate the values that are most clinically significant for masking the teeth discoloration. In 1999, Hosoya Y et al (17) stated that the borderline of color difference which is perceptible to all people is (ΔE = 2.5).

Moreover, in 1987, Ruyter IE et al (18) found that (3.3) units of color difference have been considered significant by 50% of observers. Similarly, 50% of observers have noticed the color difference of (2.72) units between the samples.

Additionally, in 2000, James C et al (19) shown that the average ΔE* between teeth assessed to be a complete color match intra-orally is (3.7) while the average ΔE* of (6.5) units has been assessed to present the clinically color mismatch.

Table 3: Comparison between the different groups according to light absorption (A).

Subgroup		Group				P3
		Group I	Group II	Group III	Group IV	
		A	A	A	A	
Dies only	Minimum	1.87	1.86	1.86	1.85	0.089
	Maximum	1.86	1.85	1.85	1.85	
	Mean	1.86	1.85	1.85	1.85	
	SD	0.01	0.01	0.00	0.00	
Veneer seated on resin dies (no bonding composite)	Minimum	1.86	1.87	1.87	1.86	0.083
	Maximum	1.85	1.86	1.86	1.86	
	Mean	1.86	1.86	1.86	1.86	
	SD	0.00	0.00	0.00	0.00	
Veneers bonded to resin dies with bonding composite	Minimum	1.82	1.84	1.74	1.82	0.001*
	Maximum	1.81	1.83	1.73	1.81	
	Mean	1.82	1.83	1.73	1.81	
	SD	0.00	0.01	0.00	0.00	
P1		0.998	0.857	0.869	0.958	
P2		0.854	0.759	0.759	0.855	

P1: Adjusted P value of t-test for dies only group & veneers seated on resin dies (no bonding composite) group
P2: Adjusted P value of t-test for dies only group & veneers bonded to resin dies group
P3: Adjusted P value of t-test for group I, II, II and IV
* P < 0.05 (significant) *: Significantly different group(s)

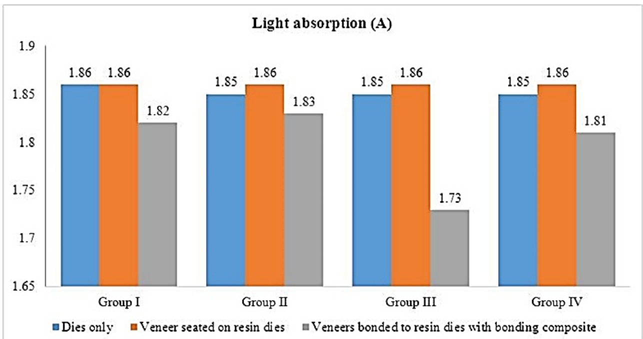

Figure 6: Comparison between the different groups according to light absorption (A).

For group I, seating the veneers on the resin dies resulted in a non-significant color change (ΔE=2.7), while bonding the veneers to the resin dies with A2 shade bonding composite resulted in a color change (ΔE=5.1) which is not clinically significant according to James C et al (19). These values might be obtained due to the similarity between the shade of the bonding composite and the shade of the resin dies.

On comparing the mean values of the color difference for groups II, III and IV, it was found that seating the veneers on the discolored resin dies had significantly changed the final color outcome (ΔE=6.6). This value was considered to be noticeable by an observer according to Ruyter IE et al (18).

For group III, bonding the veneers to the discolored resin dies with opaque white bonding composite resulted in greater color change and greater masking of the discoloration (ΔE=15.1) which is clinically significant.

While for group IV, using A2 shade bonding composite resulted in a less color change (ΔE=6.8) but still clinically significant.

On the other hand, for group II, using translucent shade bonding composite resulted least color change (ΔE=4.7) which is clinically not significant.

On comparing groups II, III and IV, the greatest change in color was for group III by the effect of the opaque shade bonding composite, followed by group IV where A2 shade bonding composite was used. Group II showed the least color change on using translucent shade bonding composite. This was in agreement with the results of Yilmaz B et al (20) who found that the final color of the veneer restorations is determined by the thickness of the veneer, the thickness and color of the luting agent and the color of the underlying tooth structure.

According to the results obtained on comparing the color difference values before and after application of the bonding composite within each group, the higher degree of conversion and the significant color changes was due to the shade of bonding composite which played the major role in the color difference due to different amounts of opacity 'ingredients' in the bonding composite with subsequent scattering of light and different values of a*,b*,L* coordinates resulting in greater change of color difference.

The results obtained in comparing groups with each other were in accordance with the results obtained by Mohammed Q et al (21), Rigoni et al (22), Eva Niu et al (23), Ajit Jankarl et al (24) who found that the use of an opaque bonding composite resulted in higher values for all color parameters evaluated when compared to the other shades of bonding composite.

However, the results of the present study were against the results of Terzioglu et al (25) who stated that the differences in the cement shade did not significantly affect the final color of the specimens. Their results may have been influenced by thickness of veneers which exceed 1.5 mm and so were capable of masking the color of the bonding cement.

Regarding light reflection and light transmission, the results showed that seating the veneers on the resin dies resulted in a non-significant change for all the four groups.

Bonding the veneers of group I, with A2 shade bonding composite resulted in a significant increase of light reflection and decrease of light transmission.

While bonding the veneers of group II and IV with translucent shade and A2 shade bonding composite resulted in a non-significant change of light reflection or light transmission. On the other hand, bonding the veneers of group III, to the discolored resin dies with opaque shade bonding composite had significantly increased the light reflection and decreased light transmission.

These results might be due to the fact that A2 shade or the translucent shade bonding composite have low amount of opacifiers, so they have no effect on light transmission or light reflection specially with the low amount of opacifiers in the veneer. While the opaque shade of bonding composite has a large amount of opacifiers, so it acts as a shield that prevents the light from transmission and increases reflected light.

These outcomes were in agreement with the results of Paul et al (26) who studied light reflection and light transmission of composite luting resin. They stated that the final color of the restorations was not dependent only on the surrounding structure and the restoration color itself but also on the color and thickness of the resin luting agent used.

While, these results were against the results of Xing W et al (27) who stated that the use of different shades of luting cement resulted in a non-significant change in light reflection or light transmission of ceromer veneers. Their results might be due to the presence of ceramic fillers in this type of composite.

Regarding light absorption, the results of the present study for all groups showed that the mean values of light absorption of the specimens were not significant. This might be due to the filler particle size of edelweiss veneer is between 0.02 – 0.03 µm (16). Also the filler particle size of the bonding composite is 0.7µm (16). These values were considered small for causing light absorption.

These results come in accordance with Kim K H et al (28) who studied the properties of composites and found that the filler particle size is responsible for light absorption where the smaller filler size, the smaller the light absorption value.

CONCLUSIONS

On using Edelweiss veneer system, the greatest change in color, light transmission and light reflection was obtained when using opaque shade bonding composite for bonding of the veneers to the substrates. While light absorption was of a non-significant value among the groups.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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