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Influence of Different Enamel Shades and Thickness on Chroma and Value of Dentin Vita Shade: An *in vitro* Comparative Assessment Study

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ABSTRACT

Background: The aim of the present study is to determine the influence of different enamel shades of various thickness on chroma and value of vita shade of dentin.

Materials and methods: Three enamel composite resin shades (Enamel white, grey and neutral) and one dentin shade (A2) from Amelogen Plus (Ultradent) was used. Ninety Enamel disk specimens of 0.5, 0.75 and 1 mm thickness and 10 mm in diameter for each shade and 90 dentin disk specimens of 2 mm in thickness and 10 mm in diameter was used for the study. The spectrophotometric values of the dentin shade with and without enamel specimens were recorded and the values were converted to CIE L*a*b values.

Results: Statistical analysis was done using Pearson correlation coefficients to verify the effect of thickness on Chroma and value, and the significance was evaluated by one-way ANOVA and Tukey post hoc test. Two way ANOVA and Tukey post hoc was done to verify the variation within the groups. Results revealed a significant positive correlation between thickness and chroma and a negative correlation between thickness and value. There was a statistically significant variation in between the groups.

Conclusion: All groups produced a significant increase in chroma with increase in thickness of enamel shade upto a thickness of 0.75 mm after which the behavior of each shade was erratic. Hence, the optimum thickness would be 0.75 mm. All groups produced a significant decrease in value with increase in thickness of enamel shade. Enamel white produced the greatest reduction in value, enamel neutral the least and enamel grey demonstrated an intermediate result.

Clinical significance: There is a need to have a knowledge of the effect on chroma and value when dentin is layered with different enamel shades, it is also important to understand the effect of these enamel shades at different thicknesses to better control the color and reproduce esthetic simulating natural teeth.

Keywords: Chroma, CIEL*a*b*, Color, Dentin, Enamel, Spectrophotometer, Value.

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INTRODUCTION

In order to reproduce a vital direct composite restoration, a clinician has to play with multiple factors, such as hue, chroma, value, opacities and translucencies.[1] Translucency is the most important factor as it generates optical phenomena which gives a life like appearance to the composite restoration and also matches the restoration to the adjacent natural tooth structure.[2]

In a natural tooth, these optical phenomena are bought about by the complex crystalline anatomy of enamel, whereas dentin is responsible for the inherent color. Enamel and dentin have different structural characteristics and, consequently, they exhibit different light wave characteristics. Enamel has mineralized prismatic structure, low organic content, a small amount of water, and more translucency, and higher transmission of light than dentin and hence produces optical phenomena; whereas dentin has less mineral content, an organic tubu-

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lar structure, higher water content and is less translucent and allows lesser transmission and more reflection of light, hence responsible to produce color.[3]

It is well established that these optical properties are different at different locations on a tooth, i.e. incisal aspect being more translucent than the cervical[4,5] and also these optical properties tend to change with age of the tooth.[2,6,7]

In an attempt to reproduce enamel properties at different locations of the tooth and in different age groups manufacturers have developed value based enamel shades to be used with a layering technique, where the more translucent enamel shades with increased light diffusion is placed over a body or opaque dentin resin composite having lower translucency, which block light rays,[3] so as to create a depth within the restoration.

Though some clinicians master this technique, pioneer clinicians struggle with the technique sensitivity as these layering techniques are affected by a variety of factors, such as translucency,[8-11] color and thickness[1,3,12,13] of each layer and end up producing restorations which are more chromatic and dull even after a correct shade selection, as there is a lack of studies on the chromatic influence of these types of resins and, therefore, the effect of the final enamel layer on the resultant color of layered resin composites.

Therefore, the aims of the present study were to: (1) To assess the effect on chroma and value of vita shade of dentin of definite thickness of 2 mm when layered with three different enamel shades (Enamel white, neutral and grey) of thicknesses 0.5, 0.75 and 1 mm.

(2) To compare and contrast this effect among different enamel shades (Enamel white, neutral and grey) at different thickness (0.5, 0.75 and 1 mm).

The null hypothesis for this study was three fold: (1) Different shades have no effect on the chroma and value of composite resin. (2) There is no effect on chroma and value of these shades at varying thickness and (3) There is no difference among different shades.

MATERIALS AND METHODS

Distribution of Group

A2 dentin, enamel white, enamel grey and enamel neutral resin composite (Amelogen plus, Ultradent) were used in the current study.

The specimens were divided into the following groups (a) control, an entire build-up of dentin composite (n = 10); (b) Group 1: Dentin with 0.5 mm thickness of enamel white shade (n = 10); (c) Group 2: Dentin with 0.75 mm thickness of enamel white shade (n = 10); (d) Group 3: Dentin with 1 mm thickness of enamel white shade (n = 10); (e) Group 4: Dentin with 0.5 mm thickness of enamel neutral shade (n = 10); (f) Group 5: Dentin with 0.75 mm thickness of enamel neutral shade (n = 10); (g) Group 6: Dentin with 1 mm thickness of enamel neutral shade (n = 10); (h) Group 7: Dentin with 0.5 mm thickness of enamel grey shade (n = 10); (i) Group 8: Dentin with 0.75 mm thickness of enamel grey shade (n = 10); (j) Group 9: Dentin with 1 mm thickness of enamel grey shade (n = 10).

Specimen Preparation

Enamel and dentin disk specimens were fabricated using metal rings which were 10 mm in diameter. Dentin disk samples were fabricated with metal rings of thickness 2 mm and enamel disk specimens were fabricated with metal rings of thickness 0.5, 0.75 and 1 mm.

The metal ring was placed on the glass slide and its chamber was filled with composite using a teflon coated (PDT Cruise) composite resin instrument. A glass slide was placed to cover the top of the composite resin and pressed for 10 seconds to achieve uniform thickness of disk specimen and to achieve a smooth glossy surface. Light curing of the composites was performed for 60 seconds (Coltolux LED, Coltene Whaledet) and output was constantly monitered.

The thickness of the specimens was confirmed with a vernier caliper (Iwason) and was stored in respective containers which was cushioned with a gauze pad.

Observation of Color

The spectrophotometric values of the dentin shade was recorded using a visible range spectrophotometer (Specord S600, Analytic Jena) over a grey background as a control. After which different enamel thickness of various shades were placed onto the dentin shade and spectrophotometric values of each specimen was recorded. Measurements were repeated three times for each specimen. The spectrophotometer was constantly calibrated using the calibration white tile supplied by the manufacturer. The obtained data were recorded by a computer connected to the spectrophotometer using software (WinAspect). The spectrophotometric values were converted to CIE L*a*b values and analyzed using Color iControl software(X-rite).

According to CIE L*a*b*, the a* axis represents the amount of red (positive values) or green (negative values) and b* represents the amount of yellow (positive values) or blue (negative values). Chroma was calculated as C*ab = (a*2 + b*2)1/2. The L* indicates the brightness of the object, ranging from 0 (black) to 100 (white). The evaluation of composite resin value (brightness) in regards to composite resin thickness was done using L*.

Table 1: Mean (standard deviation) chroma, value at different thicknesses

Composite resin	*Thickness (mm)*	*Chroma*	*Value*
Dentin	2	0.01 (0.01)	99.97 (0.02)
Enamel neutral	0.5		94.29 (0.74)
Enamel neutral	0.75	6.93 (0.61)	93.48 (0.68)
Enamel neutral	1	5.70 (0.33)	94.36 (0.57)
Enamel gray	0.5	5.22 (0.71)	94.72 (1.15)
Enamel gray	0.75	7.26 (0.59)	91.44 (0.26)
Enamel gray	1	6.71 (0.86)	91.59 (0.64)
Enamel white	0.5	5.52 (1.08)	92.12 (0.85)
Enamel white	0.75	7.14 (0.70)	92.65 (1.11)
Enamel white	1	8.41 (1.06)	90.10 (0.94)

To verify the influence of thickness on optical parameters, the Pearson correlation coefficients (r) between the thickness and chroma and thickness and value was calculated with linear regression analysis for each composite specimen.

STATISTICAL ANALYSIS

One way analysis of variance was computed for chroma and value for all studied composite resin specimen, followed by the use of Tukey post hoc test. The variance between different shades and thickness was computed using two way ANOVA and Tukey post hoc test.

RESULTS

The mean and standard deviations of the control and experimental groups for chroma (C*ab) and value (L*) are described in Table 1.

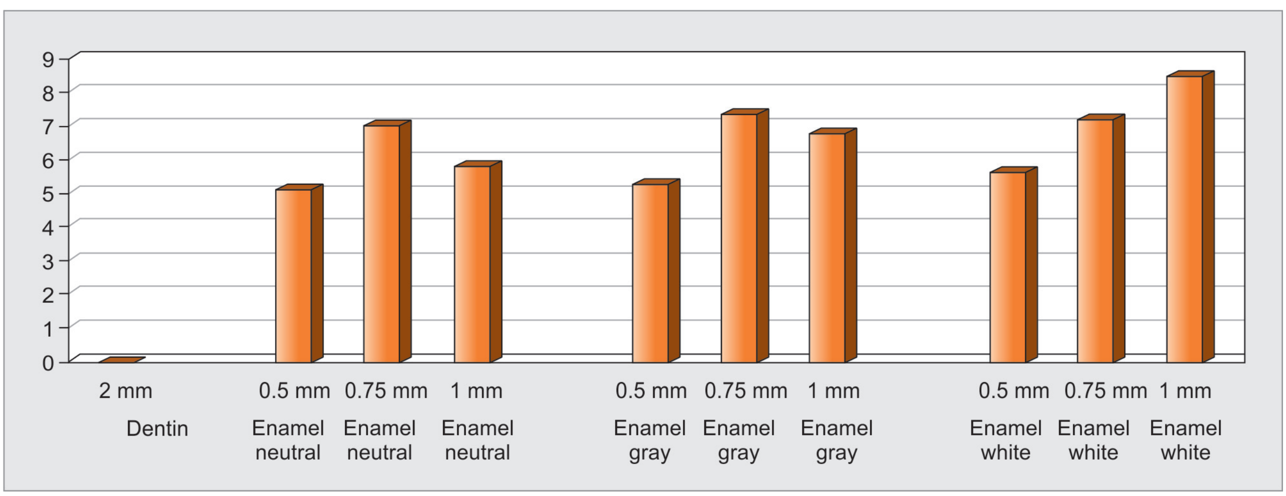
CHROMA

There was a strong, positive correlation between thickness and chroma for the tested composite resin enamel shades ($r = 0.526$, $n = 90$, $p < 0.001$). It was found that as the thickness of enamel composite increased the chroma increased for all the shades expect enamel neutral group were there was no significant difference. The Tukey post hoc test showed that the chroma was significantly lower for thickness 0.5 mm than for thickness 0.75 mm and for thickness 1 mm ($p < 0.001$). Chroma was significantly higher with thickness 0.75 mm than for thickness 1 mm ($p = 0.687$) (Graph 1).

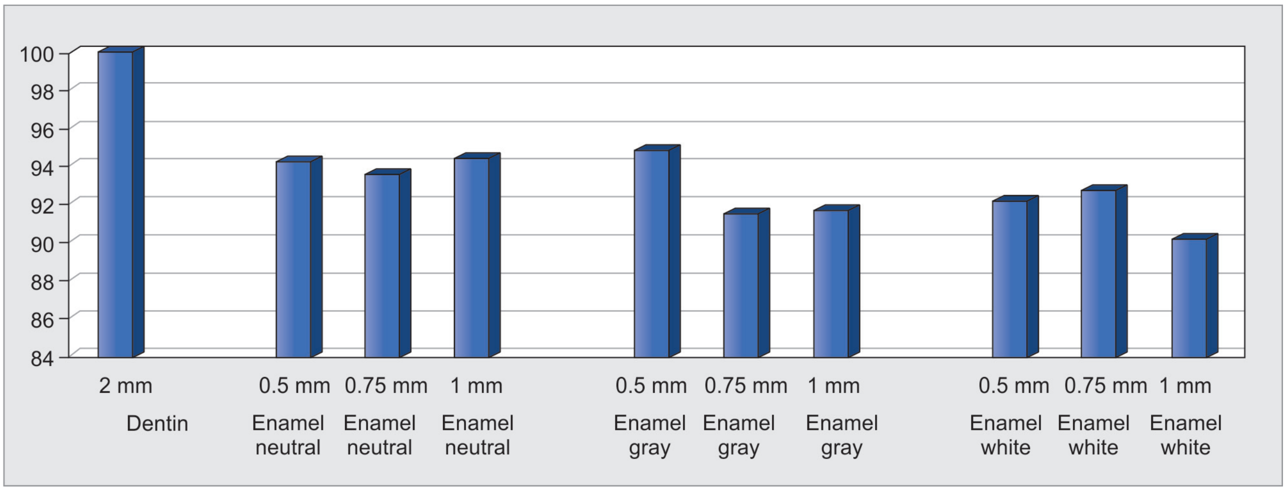
A significant effect of enamel shade on chroma was observed ($p < 0.001$). The highest increase in chroma was seen in enamel white group and lowest chroma was seen in enamel neutral group. Enamel grey presented intermediate results. The Tukey post hoc test showed that the chroma was significantly higher for dentin layered with enamel white than for dentin layered with enamel neutral and for dentin layered with enamel grey ($p < 0.05$). Chroma was significantly higher for dentin layered with enamel grey than for dentin layered with enamel neutral ($p < 0.05$).

VALUE

The pearsons coefficient of correlation showed moderate negative correlation between thickness and value (brightness) for the tested enamel composite resin



Graph 1: Mean chroma at different thickness of enamel shades



Graph 2: Mean value at different thickness of enamel shades

(r = –0.413, n = 90, p < 0.001). Increasing the thickness of enamel layers decreased the value, thus increasing the grayish aspect of final restoration. The Tukey post hoc test showed that the value was significantly higher for thickness 0.5 mm than for thickness 0.75 mm and for thickness 1 mm (p < 0.001). Value was significantly higher with thickness 0.75 mm than for thickness 1 mm (p = 0.046) (Graph 2).

There was a significant main effect of enamel shade on value (p < 0.001). The highest value was presented by enamel neutral and least by enamel white and enamel grey presented intermediate results. The Tukey post hoc test showed that the value was significantly higher for dentin layered with enamel neutral than for dentin layered with enamel white and for dentin layered with enamel grey (p < 0.001). Value was significantly higher for dentin layered with enamel grey than for dentin layered with enamel white (p < 0.001).

DISCUSSION

To reproduce the natural vital appearance and optical properties of enamel and dentin, manufacturers have developed various enamel and dentin shades, however, these composite resins lack studies on their chromatic effect.

Amelogen Plus (Ultradent) is a microhybrid composite material with eight dentin, three enamel, three translucent and one opaque shade. The three enamel shades, enamel white, enamel neutral and enamel grey resemble the natural enamel of different age groups. Young enamel has a white tint, high opalescence and low translucency, and adult enamel has neutral tint and less opalescence, whereas old enamel has greyish yellow tint and high translucency.[14]

The current study demonstrated that increasing the thickness of enamel composite resin layer, increased the chroma and decreased the value irrespective of shade. All the samples showed a decrease in value when compared to the control group (dentin group), hence demonstrated a negative correlation. Enamel neutral shade showed a decrease in the L*(value) up to a thickness of 0.75 mm which further become constant, enamel grey showed a drop in L* (value) up to a thickness of 0.75 mm and then become constant, however, for enamel white shade L*(value) kept on decreasing up to the thickness of 1 mm.

Chroma demonstrated a positive correlation with thickness, i.e. as the thickness increased the chroma increased. However, this behavior was constant only to a thickness of 0.75 mm, after which each shade showed erratic behavior. The enamel neutral demonstrated a decrease in chroma after 0.75 mm, for enamel grey the chroma remained constant after 0.75 mm, however, for enamel white, chroma kept increasing after 0.75 mm. However, the correlation of thickness, chroma and value for enamel neutral was not statistically significant.

Several studies have proved that background color affects the final shade of the restoration. A white background as might be represented by human enamel, an increase in thickness of resin results in decreasing values of luminous reflectance and excitation purity. Clinically, the resin might appear darker and less chromatic as thickness increases. However, for a black background as might be represented by the oral cavity, an increasing thickness of resin results in increasing values of luminous reflectance and excitation purity. Clinically, the resin might appear lighter and more chromatic as thickness increases.[12,13] In the present study, a grey background was used as studies have shown that the ideal background color is neutral gray. Neutral gray has no complimentary color and is restful to the cones present in retina of the eye.[15,16]

According to Johnston and Reisbick,[17] the shade and translucency of restorative materials result not only due to macroscopic phenomena, such as type and amount of inorganic filler and organic matrix but are also due to the addition of dyes and other chemicals. The coloring material and pigments within the object will absorb various wavelengths to scatter out the object.[18] In other words, the wavelength that are not absorbed are seen. The light is called scattered when it is deflected in many different directions within the object because of reflection and refraction of light in the internal interfaces. When many internal particles are present light may be scattered that is, its transmission and reflection are diminished exponentially. This may explain the change in chroma in various shades.[19]

When light encounters translucent substances, such as tooth and esthetic restorative material, four phenomena associated with the interactions of the substances with the light flux can be described: (1) specular transmission of light, (2) specular light reflection at the surface, (3) diffuse light reflection at the surface and (4) absorption and scattering of the light within the substance.[20] When light passes through a translucent material it undergoes absorption as well as scattering, light is scattered at the inclusion and absorption accentuates the light beam.[21] This light scattering is caused by particles smaller than the wavelength of visible light that are dispersed throughout the translucent matrix of a much lower refractive index. Scattering is due to refraction and reflection at the interfaces between the resin matrix and inclusions, such as filler particles and porosities.[18] This may explain the variation in behavior of different shades, the decrease in L*(value) of enamel neutral at 0.5 to 1 mm was equal to the decrease in L*(value) of enamel grey at 0.5 mm. And the decrease in the L*(value) for enamel grey at thickness of 0.75 to 1 mm was equal to the decrease in the L*(value) of enamel white at thickness of 0.75 mm. This demonstrates that enamel white produced the greatest reduction in L* (value) when compared to the other shades and enamel grey showed reduction in L*(value) greater than enamel neutral but lesser than enamel white, this results could be due to the variation in filler particles, dye and pigments. When light hits the filler particle, there is dispersive scattering within the layers and lesser light is reflected back leading to loss of luminous energy and reduced brightness. This is called luminous dispersion.

According to Horie et al[22] another reason for reduced brightness in layering technique is the increased light diffusion at the composite-composite joint. During the polymerization of resin composites, diffusion of oxygen into the resin inhibits the polymerization reaction by forming peroxide radicals. An unreacted double bond or a free monomer layer will remain after curing as the reactivity of oxygen is much higher with a radical than with a monomer. The presence of oxygen throughout light irradiation results in the formation of uncured resin-rich zone at the uppermost surface of the resin composite. This uncured resin-rich zone not only adapts the overlying material to increase the contact area, but it also allows the monomers on both sides to cross the interface and blend together to form an inter-diffusion zone, where copolymerization can take place to produce a chemical bond. As a result, an absent filler zone or resin-rich zone is formed at the composite-composite joint. When light passes through resin composite, it scatters and is absorbed at the surface of the filler particles but in the absence of filler in the resin-rich zone at the join promotes straight-line transmission of the light. Hence unlike the bulk filling technique, the composite-composite join formed with a layering technique leads to an increase in the diffusion light transmission of layered resin composites and also a reduction in translucency and a color change in the layered resin composite.

There is a need to have knowledge of the effect on chroma and value when dentin is layered with different enamel shades, it is also important to understand the effect of these enamel shades at different thicknesses to better control the color and reproduce esthetic simulating natural teeth.

CONCLUSION

Within the limitations of the current study, it can be concluded as follows:

- All groups produced a significant increase in chroma with increase in thickness of enamel shade until a thickness of 0.75 mm after which the behavior of each shade was erratic. Hence, optimum thickness of enamel layer can be considered as 0.75 mm.
- All groups produced a significant decrease in value with increase in thickness of enamel shade. Enamel white produced the greatest reduction in value, enamel neutral the least and enamel grey demonstrated an intermediate result.

Hence there is a need to have a knowledge of the effect on chroma and value when dentin is layered with different enamel shades, it is also important to understand the effect of these enamel shades at different thicknesses to better control the color and reproduce esthetic simulating natural teeth.

CLINICAL SIGNIFICANCE

The clinical significance of the present study is that thickness of more than 0.75 mm had an erratic behavior with respect different shades. Hence, thickness of 0.75 mm would be more accurate to judge and control the chroma. However, the L*(value) decreased consistently as the thickness increased, in a young patient, the enamel is thick which is responsible for the high brightness, opalescence and white tint but as the present study demonstrated a decrease in L*(value) as the thickness increased and the maximum decrease was seen with enamel white, hence a minimum thickness of 0.5 mm of enamel white should be used and the value needs to build in the dentin rather than enamel by using opaque shades. The adult patients usually present with neutral tint and moderate translucency, in the present it was found that neutral enamel demonstrate a constant behavior from thickness of 0.5 to 1 mm, hence an 0.5 to 0.75 mm enamel layer can be used to develop the optical properties. However, old patients have reduced thickness of enamel and exposed dentin which present with greyish yellow tint of the dentin and high translucency, so a greater enamel composite thickness of 0.5 to 0.75 mm can used to produce similar effects.

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