©Operative Dentistry, 2010, **35-1**, 44-49

Chromatic Influence of Value Resin Composites

M Schmeling • A Meyer-Filho
MAC Andrada • LN Baratieri

Clinical Relevance

Value resin composites used to replace enamel can induce a brightness decrease in stratified composite restoration techniques.

SUMMARY

The current study evaluated the chromatic influence of high, medium and low value composites on a dentin composite substrate (A2 shade) using spectrophotometric analysis. The specimens were divided into the following four groups: a) control (CG), entirely composed of dentin composite (n=5); b) high value (GHV), dentin composite and high value composite (n=20); c) medium value (GMV), dentin composite and medium value composite (n=20) and d) low value (GLV), dentin composite and low value composite (n=20). The dentin composite was 2.0 mm thick and the value composite was added in four different thicknesses, dividing the groups into four subgroups: S1 = 1.0 mm, S2 = 0.8 mm, S3 = 0.6 mm and S4 = 0.4 mm. The results were determined using the CIELAB system and differences in brightness of the specimens were analyzed using two-way ANOVA. Significant differences were found between different value resin composites, thicknesses and interactions, as revealed by the Tukey's test (HSD). Adding value composite produced lower brightness, and a gray shade was observed, compared to the control, regardless of the value or thickness of the primary composite. Eleven of the 12 subgroups presented clinically unacceptable chromatic changes, except when the 0.4 mm thickness of high value composite was used.

*Max Schmeling, DDS, MS, PhD student, Operative Dentistry, School of Dentistry, Federal University of Santa Catarina, Florianópolis, SC, Brazil

Alfredo Meyer-Filho, DDS, MS, PhD, adjunct professor, Dental Clinics, School of Dentistry, Federal University of Santa Catarina, Florianópolis, SC, Brazil

Mauro Amaral Caldeira de Andrada, DDS, MS, PhD, professor, Operative Dentistry, School of Dentistry, Federal University of Santa Catarina, Florianópolis, SC, Brazil

Luiz Narciso Baratieri, DDS, MS, PhD, professor, Operative Dentistry, School of Dentistry, Federal University of Santa Catarina, Florianópolis, SC, Brazil

*Reprint request: CCS, Campus Trindade, UFSC 88040900, Florianopolis, SC, Brazil; e-mail: maxschmeling@globo.com

DOI: 10.2341/09-44-L

INTRODUCTION

Knowing the optical phenomena that determines the chromatic expression of tooth tissues and their clinical application is essential to achieving esthetic excellence in restorative treatment.

Enamel and dentin have different structural characteristics and, consequently, they exhibit different light wave characteristics. Due to its highly mineralized prismatic structure, low organic content and a small amount of water, enamel has a higher transmission of light than dentin; dentin has less mineral content, an organic tubular structure, higher water content and is less translucent.[1]

Following the natural features, the resin composites used for dentin build-up are characterized by lower translucency, and they block light rays, while the resin composites for enamel are highly translucent, increasing light diffusion inside the restoration.[2-3]

In an attempt to reproduce enamel properties, direct resin composite systems with high, medium and low value composites, were introduced. However, there is a lack of studies about the chromatic influence of these types of resins.

To evaluate this influence, different thicknesses of value resin composites were applied on an A2-shaded dentin resin composite. The aims of the current study were to: 1) evaluate the influence of thickness of a value resin composite on the perception of substrate brightness and 2) observe the influence of a value resin composite on the chromatic perception of the substrate. The null hypothesis was that adding value resin composite does not increase the substrate brightness.

METHODS AND MATERIALS

Distribution of Groups and Subgroups

A2 dentin (Lot #K00673), High value (Lot #J27780), Medium value (Lot #H25492) and Low value (Lot #H15575) resin composites (4 Seasons, Ivoclar Vivadent, Schaan, Liechtenstein) were used in the current study.

The specimens were divided into the following groups: a) control (GC), an entire build-up of dentin composite (n=5); b) high value (GHV), build-up with dentin composite and high value composite (n=20); c) medium value (GMV), build-up with dentin composite and medium value composite (n=20); d) low value (GLV), build-up with dentin composite and low value composite (n=20). Dentin composite was built-up to a 2.0 mm thickness, and the value composite was built-up to four different thickness, dividing the groups into four subgroups: a) subgroup 1 (S1) = 1.0 mm; b) subgroup 2 (S2) = 0.8 mm; c) subgroup 3 (S3) = 0.6 mm and d) subgroup 4 (S4) = 0.4 mm.

Specimen Preparation

The specimens were fabricated using a stainless steel matrix designed to produce resin composite disks (Figure 1). The matrix presented a 12 mm diameter circular platform that could be retracted, producing a cavity that could be filled with resin composite to different thicknesses.

To produce the control group, the platform was retracted 2.0 mm and was filled with dentin resin composite. A glass slab was then pressed by finger pressure,

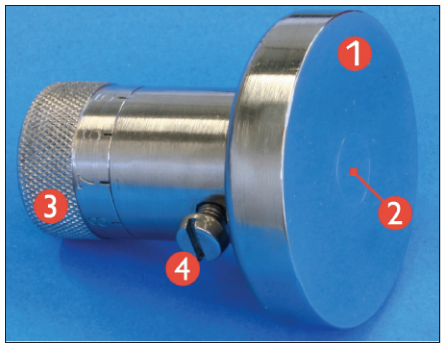

Figure 1: *Stainless steel matrix designed to produce resin composite disks in different thicknesses: 1. Base; 2. Central platform; 3. Caliper and 4. Security lock.*

followed by 10 seconds of weight application using a 100-g weight steel block to achieve a uniform thickness of the disk specimens. Light curing of the composite was performed for 60 seconds (3M Curing Light 2500, 3M Dental Products, St Paul, MN, USA) and the light output was constantly monitored (600mW/cm^2).

The formation of test groups was (randomly assigned) performed initially by dentin resin disks presenting the same characteristics as the control group. However, after light-activation, the depth of the central platform was increased according to the desired thickness of the increment of each value composite. After filling the cavity with value resin composite over the dentin resin, the glass plate was placed again and the value resin was light-cured for 40 seconds. This protocol was followed for all three test groups for the four thicknesses.

Observation of Color

A series of color measurements was accomplished using an integration sphere spectrophotometer covered by barium sulfate (Minolta CM 2600D, Tokyo, Japan). The Illuminant D65 was used to represent natural light.[4] The measurements were performed with a specular component, therefore, no polishing technique was performed in the specimens after curing. This procedure avoided variation of the superficial texture of the specimens, which could influence the results of the color evaluation.[5]

To exclude eventual relative inconsistencies from the device and the operator, three different spectrophotometric measurements were accomplished consecutively in each specimen. The color of each specimen was then obtained by acquiring the average of the three measurements and expressing them according to the CIELAB standard.

Calibration of the equipment was performed immediately before the series of measurements by using a white tile supplied by the manufacturer (Minolta CM 508D). After the procedure, all measurements of the control group and test groups were repeated on other specimens in the control group, obtaining the background contrast.[6] The obtained data were recorded by a computer connected to the spectrophotometer using software (Spectra Match Minolta System, version 3.4.1 D, Cyber Chrome Inc, Bradford, CT, USA).

Calculation and Evaluation of Chromatic Differences

According to CIELAB,[4] colors are expressed in three related axes that cross to determine the color of the object. The L* axis indicates the achromatic coordinate or lightness of the object, ranging from 0 (absolute black) to 100 (absolute white). The a* and b* axes indicate the chromatic coordinates and indicate the three-dimensional positioning of the object in the color space. The a* axis represents the amount of red (positive a* value) or green (negative a* value). The b* axis represents the amount of yellow (positive b* value) or blue (negative b* value).

For evaluation of the color differences, the spectrophotometric measurements were analyzed by calculating the ΔE*, as follows:

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

where:

ΔL*=L*1-L*2 (L* coordinate of the Control Group –L* coordinate of the test group)

Δa*= a*1-a*2 (a* coordinate of the Control Group –a* coordinate of the test group)

Δb*= b*1-b*2 (b* coordinate of the Control Group –b* coordinate of the test group)

To verify the clinical significance of the obtained results, the values of ΔE* <1 were regarded as not appreciable by the human eye. Values 1 <ΔE* <3.3 were considered appreciable by skilled operators but were considered clinically acceptable, while values of ΔE* >3.3 were considered appreciable also by non-skilled persons and, for that reason, they were clinically not acceptable.[7]

Table 1: *CIELAB Values Obtained From the Average of the Three Spectrophotometric Measurements of the Control Group, Test Groups and Their Corresponding Subgroups*

Groups	Subgroups	L*	a*	b*
GC		71.4(0.2)	1.9(0.1)	16.1(0.1)
GHV	SH1	65.4(0.4)	1.5(0.1)	8.8(0.4)
	SH2	66.6(0.4)	1.5(0.1)	10.3(0.2)
	SH3	67.6(0.5)	1.6(0.2)	10.5(0.5)
	SH4	69.0(0.4)	1.6(0.2)	12.1(0.4)
GMV	SM1	64.1(0.5)	1.0(0.1)	8.8(0.4)
	SM2	65.2(0.2)	1.1(0.1)	9.7(0.2)
	SM3	66.7(0.2)	1.2(0.1)	10.8(0.3)
	SM4	68.2(0.5)	1.2(0.2)	11.8(0.3)
GLV	SL1	60.8(0.6)	1.0(0.1)	9.0(0.2)
	SL2	63.0(0.5)	1.1(0.1)	10.6(0.3)
	SL3	64.2(1.1)	1.2(0.1)	10.9(0.5)
	SL4	66.4(0.6)	1.2(0.3)	12.3(0.4)

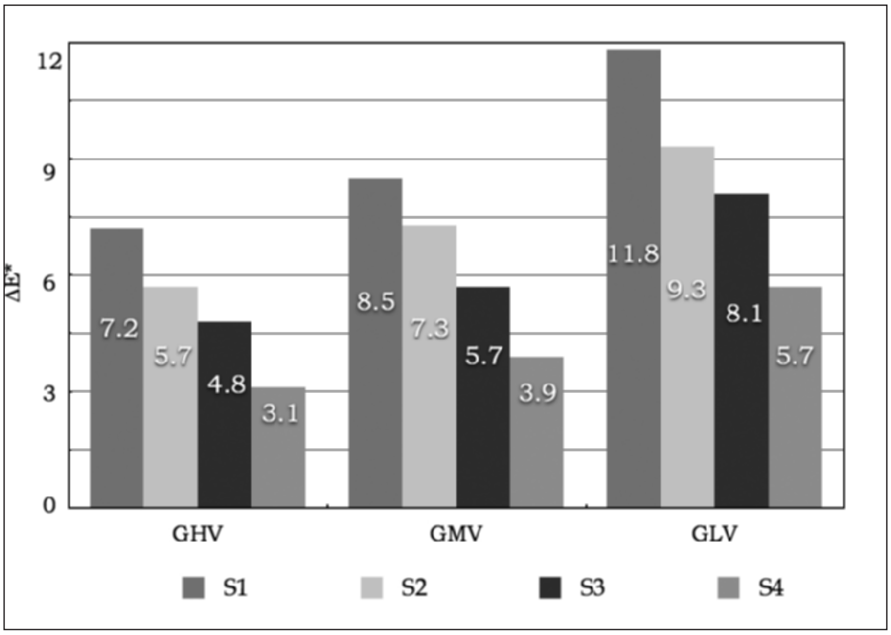

Figure 2. *Color differences (ΔE*) between the control group and test groups.*

RESULTS

The resulting CIELAB values obtained from an average of the three spectrophotometric measurements of the control group, test groups and their corresponding subgroups, are described in Table 1.

The chromatic differences (ΔE*) between the control group and test groups can be seen in Figure 2.

The statistical analysis of the brightness of the samples (L* axis) was accomplished using two-way ANOVA ($p<0.05$). The variables were resin values (3 modalities: high, medium and low) and increment thickness (4 modalities: 1.0 mm; 0.8 mm; 0.6 mm and 0.4 mm). ANOVA results indicated that there were significant differences among the different values of resins, thicknesses and their interactions ($p<0.00001$), as revealed by the Tukey Honestly Significance Difference (HSD) post-hoc test.

The different values of resin composites demonstrated statistically significant differences ($p<0.001$). The specimens with high value composite presented greater brightness than medium and low value resin composites, and they were also statistically different from each other (HSD: GHV = 67.2; GMV = 66.1; GLV = 63.7).

The thickness of the composite presented statistically significant differences ($p<0.001$). The 0.4 mm thickness specimens presented higher brightness values than the others, followed by the 0.6; 0.8 and 1.0 mm thickness specimens in decreasing order (HSD: S4 = 67.9; S3 = 66.2; S2 = 65; S1 = 63.5).

The interaction between the chromatic designations and the different thicknesses also demonstrated statistically significant differences ($p<0.01$) and are described in Table 2.

DISCUSSION

The search for natural-looking restorations led to the recent introduction of a number of restorative systems containing several shades and different translucency levels, including enamel resin composites of high, medium and low value.

The current study demonstrated that the test groups presented lower L* values than the control group, regardless of the enamel resin being evaluated and, as a consequence, the null hypothesis was accepted. Lower b* axis values, with discrete changes in the a* axis, were also observed.

According to the results, 11 of the 12 tested subgroups presented chromatic differences that were considered clinically unacceptable, that is, greater than 3.3 CIELAB units ($\Delta E^*>3.3$), except for the subgroup SH4 (high value enamel composite, 0.4 mm thickness). The chromatic difference recorded in this subgroup was shown to be the result of the interaction of the resin and the thickness, causing a greater amount of observed light reflection.

The lowest L* values observed in the test groups when compared to the control group might have occurred due to the dispersion of the luminous energy, which is inherent to translucent objects.[8-10] The application of enamel resin over dentin resin was responsible for the increased light dispersion. When this dispersion occurs, the energy is reflected diffusely, returning randomly from the specimen surface, commonly beyond the observation range of the spectrophotometer. Similar to the visual observation method, loss of the luminous energy happens as a result of limitations of the spectrophotometric observation window that was described earlier[11] in a study accomplished with natural teeth. This limitation was called edge loss. Although no statistical analysis was accomplished for the chromatic axes (a* and b*), the lowest values presented by the b* axis probably can be explained by the relationship between the yellow wavelengths and the "edge loss" effect.

Ikeda and others[2] analyzed the color and translucency of A2 and OA2 direct resin composites of three different systems using a colorimeter. The results indicated that the OA2 resin composites presented higher L* values than the A2 resins. Similar to the current study, those authors also attributed the lower L* values presented by enamel resins to the greater translucency of the material, which resulted in the energy dispersion and lower reflection observed.

When the test groups were compared to each other, the GHV group presented higher L* values than the GMV group, which, in turn, presented higher L* values than the GLV group, regardless of the thickness. However, when the comparison was performed among the subgroups, an inverse relationship was observed between the thickness and L* values. In other words, an increased thickness of value resin led to lower L* values observed in the specimens, regardless of the value of the resin composite that was used. Therefore, the current study corroborates another study[5] that described increased thicknesses of resin resulted in the increased brightness, which was observed when the material was placed on a black background, simulating the oral cavity. Conversely, increased thicknesses of the composite resulted in lower brightness when the resins were observed over a white background, simulating teeth and restorative materials.

The thickness of higher value resin composite on the A2-shade dentin resin resulted in clinically acceptable chromatic differences between some subgroups ($\Delta E^*<3.3$). Therefore, the chromatic influence presented by a high value resin with a 1.0 mm thickness was similar to the medium value resin

Table 2: *Differences in L* Values for the Interaction of Value Resin Composites and Different Thicknesses*

Subgroup								Result
SH4	a							69.1
SM4		b						68.3
SH3		b						67.7
SL4			c					66.7
SM3			c					66.7
SH2			c					66.4
SH1				d				65.5
SM2				d				65.2
SL3					e			64.3
SM1					e			64.2
SL2						f		63.1
SL1							g	60.8

Levels not connected by the same letters indicate L differences according to the Tukey Honestly Significance Difference (HSD) post-hoc test ($p<0.01$).*

with a 0.8 mm thickness and the low value resin with 0.6 mm thickness. This demonstrates that similar equal chromatic perception can be obtained, regardless of the type of value resin composite used. According to the results, it is possible to restore enamel by simply varying the thickness of the resin increment, regardless of the value.

In natural teeth, value or brightness characterizes enamel, while the chroma and hue characterizes dentin.[12-15] Young people who are less exposed to damage caused by acids in the diet and by brushing have thicker enamel than older people and, consequently, lighter teeth. While wear decreases the thickness of enamel, the translucency of enamel increases, enabling the chroma and hue, which are features related to dentin, to become more obvious. Thus, during the interaction of light with dental tissues, enamel plays the important role of acting as a filter whose greater or lesser thickness accounts for more or less bright teeth.[16]

It has been proposed that the use of different stratified restorative techniques using direct resin composites can provide excellent results. Dietschi and others proposed the Natural Stratification Technique, where they used dentin and enamel composites to replace the same amount of actual lost dentin and enamel as the best way to reproduce the physical and optical features of the dental tissue. However, the results of the current study suggest that, clinically, use of the Natural Stratification Technique should be performed with caution when value composite is used to restore the enamel layer. Unlike what happens in the dental structure, where a thicker enamel layer represents whiter teeth and greater brightness,[12-15] increased thicknesses of value resin layers produced lower brightness, and less yellow color was observed from the A2-shades resin substrate, compared to the control group.

Vanini[18] and Magne and Holz[19] recommended the use of an opaque resin that is "two chromatic points" more saturated than the basic color of the tooth during the stratification process of the dentin layer. For instance, when the basic color of the tooth is A3, an A5 or even A6 dentin resin should be used for proper reproduction of the internal chromatic effect. That technique is based on the potential for further enamel resin composite layers to "clear" the dentin composite substratum. Unlike what was described by Vanini[18] and Magne and Holz,[19] the current results demonstrate that value resin composites should not be used for this purpose on an A2-shade resin composite substratum. This observation is based on the limitations of obtaining the suggested "bleaching effect" by using this material at the evaluated thicknesses.

CONCLUSIONS

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

1. The addition of value resin composites and increasing thickness of these layers was responsible for reduced brightness of the substratum. Clinically unacceptable chromatic changes appeared when the test groups were compared to the control group, except when a 0.4 mm thick high value composite increment was used.
2. The addition of value composite increments also caused a reduction in the yellow color and a corresponding increase in the gray appearance.

(Received 5 February 2009)

References

1. Vaarkamp J, ten Bosch JJ & Verdonschot EH (1995) Propagation of light through human dental enamel and dentine *Caries Research* **29(1)** 8-13.
2. Ikeda T, Sidhu SK, Omata Y, Fujita M & Sano H (2005) Colour and translucency of opaque-shades and body-shades of resin composites *European Journal of Oral Sciences* **113(2)** 170-173.
3. Sidhu SK, Ikeda T, Omata Y, Fujita M & Sano H (2006) Change of color and translucency by light curing in resin composites *Operative Dentistry* **31(5)** 598-603.
4. Commission Internationale de L'Eclairage (1971) *Official Recommendations of the International Commission on Illumination* **Publication CIE No 15** (E-1.3.1).
5. Powers JM, Dennison JB & Lepeak PJ (1978) Parameters that affect the color of direct restorative resins *Journal of Dental Research* **57(9)** 876–880.
6. Lee YK, Lim BS & Kim CW (2005) Difference in the colour and colour change in dental resin composites by the background *Journal of Oral Rehabilitation* **32(2)** 227-233.
7. Ruyter IE, Nilner K & Moller B (1987) Color stability of dental composite resin materials for crown and bridge veneers *Dental Materials* **3(5)** 246–251.
8. Campbell PM, Johnston WM & O'Brien WJ (1986) Light scattering and gloss of an experimental quartz-filled composite *Journal of Dental Research* **65(6)** 892-894.
9. ten Bosch JJ & Coops JC (1995) Tooth color and reflectance as related to light scattering and enamel hardness *Journal of Dental Research* **74(1)** 374-380.
10. Lee YK (2007) Influence of scattering/absorption characteristics on the color of resin composites *Dental Materials* **23(1)** 124-131.
11. Van der Burgt TP, ten Bosch JJ, Borsboom PC & Kortsmit WJ (1990) A comparison of new and conventional methods for quantification of tooth colour *Journal of Prosthetic Dentistry* **63(2)** 155-162.
12. Hasegawa A, Ikeda I & Kawagushi S (2000) Color and translucency of natural central incisors *Journal of Prosthetic Dentistry* **83(4)** 418-423.

13. Jahangiri L, Reinhardt SB, Mehra RV & Matheson PB (2002) Relationship between tooth shade value and skin color: An observational study *Journal of Prosthetic Dentistry* **87(2)** 149-152.

14. Dozic A, Kleverlaan CJ, Aartman IHA & Feilzer AJ (2004) Relation in color of three regions of vital human incisors *Dental Materials* **20(9)** 832-838.

15. Dozic A, Kleverlaan CJ & Aartman IHA & Feilzer AJ (2005) Relation in color among maxillary incisors and canines *Dental Materials* **21(3)** 187-191.

16. Baratieri LN, Araújo EM Jr & Monteiro S Jr (2007) Color in natural teeth and direct resin composite restorations: Essential aspects *European Journal of Esthetic Dentistry* **2(1)** 172-186.

17. Dietschi D, Ardhu S & Krejci I (2006) A new shading concept based on natural tooth color applied to direct composite restorations *Quintessence International* **37(2)** 91-102.

18. Vanini L (1996) Light and color in anterior composite restorations *Practical Periodontics and Aesthetic Dentistry* **8(7)** 673-682.

19. Magne P & Holz J (1996) Stratification of composite restorations: Systematic and durable replication of natural aesthetics *Practical Periodontics and Aesthetic Dentistry* **8(1)** 61-68.