Original Research Article

Effect of Bevel Preparation on Color Adjustment Potential of One-Shade Composites

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ABSTRACT

Aim: This study aimed to evaluate the effect of bevel preparation on the color adjustment potential (CAP) of three universal one-shade and one conventional resin composite used in anterior restorations.

Materials and Methods: Three universal one-shade (Omnichroma, Vitra APS Unique, Charisma Topaz One and one conventional resin composite (Estellite Sigma Quick) were tested. Standardized cavities (6 mm diameter, 2 mm depth) were prepared in A2-shade acrylic molds, either without bevel or with a 2 mm, 45° bevel. Each group consisted of ten specimens (n=10). Restorations were placed in a single increment, light-cured, polished, and stored in distilled water for 24 hours. Color parameters (L*, a*, b*) were measured using a spectrophotometer (VITA Easyshade V), and ΔE values were calculated with the CIEDE2000 formula. The color adjustment potential index (CAP-I) was determined as CAP-I = 1 − (ΔE$_{DUAL}$/ΔE$_{SINGLE}$). Data were analyzed using the t- test, ANOVA and Tamhane post hoc tests (α=0.05).

Results: CAP-I values ranged from 0.57 to 0.86 in non-beveled and 0.85 to 0.94 in beveled groups. No statistically significant differences were found between bevel and and non-bevel designs except Omnichroma group (p=0.003). Omnichroma showed the lowest CAP in non-beveled groups (p<0.05), whereas Estellite demonstrated the highest overall values.

Conclusion: Bevel preparation did not significantly affect the color adjustment potential of tested composites except Omnichroma groups. The optical characteristics of restorative materials appear to have a greater influence than cavity design on esthetic blending. Therefore, appropriate composite selection remains critical for achieving natural integration in anterior restorations.

Keywords: Color; Composite dental resin; Dental cavity preparation

INTRODUCTION

Composite restorations are widely used in modern restorative dentistry for preserving sound tooth structure and replicating the natural tooth's optical and mechanical properties.[1] They support the principles of minimally invasive treatment through conservative cavity designs, durable adhesive strategies, and biomimetic concepts that aim to restore both function and esthetics.[2] In the anterior region, patients have high esthetic expectations, so color adjustment is critical for patient satisfaction. Among these esthetic considerations, achieving a harmonious color match between the resin composite

(RC) and the surrounding tooth is essential for clinical success.[3] However, this is often challenging due to the limited range of available shades and the multifactorial nature of tooth color, which is influenced by factors such as tooth type, location, age, and the distinct optical properties of enamel and dentin.[4] The final perceived color results from complex light interactions, including diffuse reflectance from the underlying dentin through the translucent enamel layer, making accurate shade matching between RC and natural teeth a demanding aspect of restorative dentistry.[2,4]

To help overcome these challenges, various changes have been made to the formulation of resin composites in recent years.[1] One of the most notable developments is the introduction of pigment-free, one-shade composites.[5,6] These universal one-shade composites are designed to match a wide range of shades (from A1 to D4) using a single syringe , eliminating the need for multiple shades and simplifying the restorative procedure.

One-shade composites take advantage of the blending effect, where the restoration's optical properties interact with the surrounding tooth to create a smooth visual transition, making restoration margins natural.[2] This phenomenon is closely related to the concept of color adjustment potential, which describes the ability of a resin composite to harmonize with adjacent tooth tissues through light scattering, translucency, and internal reflection.[7]

Color adjustment potential (CAP) refers to the color-matching phenomenon of resin composites, which involves the mutual reflection and shift of optical properties between the RC restoration and the surrounding tooth structure. One-shade composites with their color adjustment feature make clinical procedures easier by reducing the effort needed for shade selection.[6] CAP is not only relevant for immediate shade matching but also plays a crucial role in maintaining long-term esthetic stability, as materials with higher blending ability are better able to tolerate minor color changes in both the composite and the surrounding tooth structure over time.[8] Their ability to adapt to different tooth colors lessens esthetic concerns and helps achieve satisfactory results in daily practice.[6,7]

Despite these advantages, achieving invisible margins remains a challenge, particularly in anterior teeth where esthetic demands are highest. In this context, cavity design plays a crucial role, and the placement of a cavosurface margin bevel has traditionally been recommended in literature for more effective retention, reducing microleakage, and improving esthetics, especially in anterior regions.[9-11] However, advancements in adhesive technology have made it possible to place adequate restorations without bevels, resulting in more conservative preparations.[12,13] With the focus on minimally invasive approaches and the improved optical properties of modern restorative materials, the need for bevel application in anterior restorations has become questionable.[12,14]

Previous studies have highlighted the role of beveling in enhancing the esthetic integration of anterior restorations, while recent research has focused on the color adjustment potential of one-shade composites with advanced optical properties.[9,15,16] However, there is limited evidence regarding the influence of beveling on the color adjustment potential of these new restorative materials.[5-7]

Therefore, the present study aimed to investigate whether (I) bevel design and (II) composite type influence the color adjustment potential of three one-shade and one conventional resin composites with color adjustment future. Two null hypothesis were evaluated:

H0₁: Bevel design (beveled vs non-beveled) does not significantly affect the color adjustment potential of tested resin composites.

H0₂: There are no significant differences in the color adjustment potential among the four tested resin composites

MATERIALS AND METHODS

This laboratory-based study included four commercial resin composites: Omnichroma (Tokuyama Dental, Japan), Vitra APS Unique (FGM Dental Group, Brazil), Charisma Topaz One (Kulzer, Germany), Estellite Sigma Quick (Tokuyama Dental, Japan) with a color adjustment potential future. The composition and manufacturer details for the materials employed in this study are listed in Table 1. Fig. 1 illustrates

Table 1. Materials used in the study

Product	Shade	Filler content-filler (wt%/vol%)	Monomer Type	Manufacturer	Batch No.
Omnichroma	-	Spherical SiO2 -ZrO2 Particle size of 260 nm- (79%/68%)	UDMA, TEGDMA	Tokuyama Dental, Shibuya, Tokyo, Japan	2409
Vitra APS Unique	-	Zirconia filler (200 nm), Silica - (72-80%/50-60%)	UDMA, TEGDMA	FGM, Joinville, Brazil	040723
Estelite Sigma Quick	A2	Spherical SiO2 -ZrO2 Particle size of 100-300 nm - (82%/71%)	Bis-GMA, TEGDMA	Tokuyama Dental, Shibuya, Tokyo, Japan	E9024
Charisma Topaz One	-	Barium aluminum fluoride glass filler of 0.02–2 µm, 5 vol% pyrogenic silicon dioxide filler of 0.02–0.07 µm -(81%/64%)	UDMA, TCD-DIHEA, TEGDMA	Kulzer, Hanau, Germany	N010302
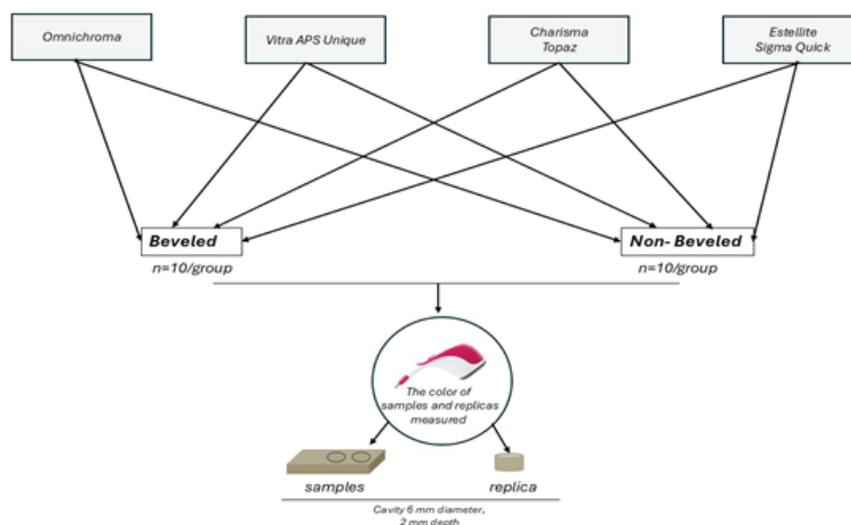
Fig 1. Flow chart of the experimental design

the study design, showing the flow of specimens through the various stages of the experiment. In order to create dual and replica samples, molds were designed and produced with a 3D printer (HP Jet Fusion, HP Inc., Germany) as follows; non-beveled and 2 mm beveled. The cavities in the molds were prepared with a diameter of 6 mm, a depth of 2 mm, and with or without 2 mm 45⁰ beveling for dual samples The sample size was calculated using G*Power (version 3.1.9.7, Kiel University, Kiel, Germany) and the one-way analysis of variance (ANOVA) for four groups based on the findings of a previous study.[17] The effect size was effect size of d = 0.55, a sample size of 10 was sufficient to achieve 95% power at α =0.05.

Then, in order to ensure standardization, mold negatives get prepared with silicone impressions (Zetaplus, Zhermack, Germany), and then final molds to which the restorations will be applied were prepared with autopolymerizing acrylic (Dentalon plus, Heraus Kulzer, Germany), which is a temporary crown and bridge material in A2 shade. Samples with and without a 2 mm bevel were produced by resin composites of each group. For the dual sample measurements, designated measurement areas within the acrylic molds were utilized. The composites were placed into the cavity as a single increment, and the microscope slide and mylar strip were applied with slight pressure. All specimens were light-cured with a light-emitted diode unit

(D-Light Pro, GC Corporation, Japan) used in the standard mode (1400 mW/cm^2) for 20 s. Previously described silicone molds were used to obtain single specimens. To remove the mylar layer, the finishing/polishing procedure is applied to the composite surface with Sof-Lex Contouring and Polishing Disks (3M™ ESPE, USA) at medium, fine, and super-fine grit discs under water cooling at a speed of 10.000 rpm for 20s. Following the restorations, the specimens were kept in distilled water at room temperature for 24 hours.

All data collection was performed by a single operator in a controlled environment with standardized D65 illumination (6500K). Prior to the measurements, the spectrophotometer (VITA Easyshade V, VITA Zahnfabrik, Germany) was calibrated to ensure accuracy. The color parameters (L*, a*, b*) were obtained from the central area of each specimen against a white background and subsequently converted to CIEDE2000 values as follows:

In the ΔE formula, the terms ΔL, ΔC, and ΔH represent the differences in lightness, chroma (saturation), and hue, respectively. The R_T value accounts for the interaction between chroma and hue differences. The parametric factors Kl, Kc, and Kh are typically set to 1 under standard conditions.

The instrumental color adjustment potential (CAP-I) parameter was calculated using the CIEDE2000 equation with values of the sample as follows:

For each specimen group (2 mm beveled, non-beveled, single, and dual), ten samples were prepared (n=10). All measurements were performed by the same operator, repeated three times, and the mean values were calculated and recorded as the color values of each specimen.

In the evaluation of color adjustment potential (CAP), color differences were calculated using ΔE values. Specifically, ΔE_{SINGLE} refers to the color difference between a single composite specimen and the reference (unrestored acrylic space), while ΔE_{DUAL} represents the color difference between a composite-restored cavity (dual specimen) and the same unrestored acrylic space.

All statistical analyses were carried out using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA), with a significance level of p<0.05.
The Shapiro–Wilk test showed that the data were normally distributed (p>0.05). Independent samples t-tests were performed for each composite to compare beveled and non-beveled groups. Additionally, one-way ANOVA was used within each margin design group (beveled or non-beveled) to compare the four composite materials, followed by Tamhane's post-hoc test when variances were unequal.

RESULTS

The CAP-I values for each composite material under non-beveled and beveled conditions are summarized in Table 2. Welch independent samples t-tests demonstrated that bevel preparation produced a statistically significant increase in CAP-I only for Omnichroma (p=0.003), whereas no significant differences were observed between beveled and non-beveled groups for Vitra (p=0.32), Charisma Topaz One (p=0.45), or Estellite Sigma Quick (p=0.27). One-way ANOVA indicated that composite type significantly affected CAP-I in non-beveled restorations (p = 0.009), while no significant inter-material differences were detected in beveled restorations (p=0.15). These findings indicate that bevel preparation does not uniformly enhance the

Table 2. Mean color adjustment potential (CAP-I) values and standard deviations of tested composites with different cavity margin designs

	CAP-I		
Groups	Non-beveled	2- mm bevel	p-value (Beveled vs Non-Beveled
Omnichroma	0.57 ± 0.10[a,A]	0.87 ± 0.01[B]	0.003
Vitra APS Unique	0.80 ± 0.09[b,A]	0.85 ± 0.09[A]	0.120
Charisma Topaz	0.82 ± 0.17[b,A]	0.87 ± 0.07[A]	0.400
Estellite	0.86 ± 0.14[b,A]	0.94 ± 0.04[A]	0.05

*Different lowercase letters shown as superscripts on the column indicate a statistically significant difference by (Welch) t-test (p<0.05; two-sided)

**Different uppercase letters shown as a superscripts on the line indicate a statistically significant difference

color adjustment potential of tested composites and that material-dependent differences are more prominent in non-beveled cavities.

DISCUSSION

In esthetic dentistry, achieving imperceptible margins and harmonious color integration remains one of the greatest challenges, particularly in anterior restorations where patient expectations are high.[18] To address these demands, recent advances have focused both on developing one-shade resin composites with enhanced optical properties and on evaluating cavity preparation designs, such as beveling, that may improve the blending effect and esthetic outcome.[19] However, preparation design alone cannot ensure perfect integration, because the optical properties of the restorative material—such as translucency, opalescence, and especially its color adjustment potential (CAP)—play a decisive role.[20]

In this context, the concept of CAP has gained increasing attention, reflecting the ability of a composite to harmonize with surrounding tooth structures and enhance the blending effect.[7] CAP can be assessed by two main approaches: visual evaluation and instrumental analysis. While visual methods rely on subjective perception and can be influenced by individual variability, instrumental methods provide more objective and reproducible measurements.[21] In the present study, CAP was determined using instrumental analysis; therefore, a spectrophotometer (VITA Easyshade V) was employed for shade evaluation. Objective color-measurement devices such as spectrophotometers—particularly the VITA Easyshade V—have been shown to provide standardized and reproducible shade selection, reducing the subjectivity of visual assessment.[22] VITA Easyshade V demonstrates high reliability and accuracy and has been validated to produce the most precise, repeatable, and clinically acceptable results among available devices.[23]

The CIELAB color system has long been used to quantify tooth color differences; however, it shows limitations in accurately reflecting human visual perception, particularly for the subtle color variations critical in dental applications. To address these shortcomings, the International Commission on Illumination (CIE) introduced the CIEDE2000 formula,

which incorporates corrections for hue, chroma, and lightness interactions, along with a weighting factor to improve perceptual uniformity.[4] With the increasing emphasis on precise color matching, CIEDE2000 has become the most widely accepted method for defining perceptibility and acceptability thresholds in dental research.[24] Although CIELAB calculations are still commonly used, CIEDE2000 was employed in our study to provide a more perceptually relevant assessment of color differences.

One-shade composites were developed to simplify shade selection in clinical practice while maintaining esthetically acceptable outcomes. These materials differ significantly from traditional multi-shade composites, as they exhibit wavelength-dependent optical behavior with distinct translucency and opalescence parameters.[18] "Smart monochromatic" composites represent a newer category based on smart chromatic technology, which captures the structural color of surrounding enamel through filler particle size-dependent light scattering, without added pigments. Omnichroma, first marketed in 2019, is a pigment-free one-shade composite that relies on the chameleon effect to achieve superior shade-matching ability.[20] Similarly, Vitra APS Unique (FGM) and Charisma Topaz One (Kulzer) are universal one-shade composites designed to simplify shade selection; Vitra incorporates zirconia and silica fillers, while Charisma Topaz utilizes a TCD-based monomer matrix to enhance physical and optical properties.[6,18] In contrast, Estelite Sigma Quick (Tokuyama) is a conventional submicron-filled composite, included in this study as a reference material due to its established esthetic track record.[5,17]

Translucency significantly influences the CAP of composite restorations. An optimal level of translucency facilitates the uptake of surrounding tooth color, enhancing the blending effect, whereas excessively opaque or overly translucent materials compromise this integration.[25] In their study comparing one-shade composites, Lucena et al.[18] reported that Omnichroma exhibited the highest translucency, which decreased with increasing material thickness. In the present study, Omnichroma showed the lowest CAP-I values in the non-bevel design, while in the 2 mm bevel design it demonstrated comparable CAP to other materials tested, suggesting that translucency at

this thickness was insufficient for ideal adaptation. One-shade composites such as Omnichroma can achieve clinically acceptable color matching, but performance depends on factors including cavity depth and surrounding shades.[5] Therefore, optimal CAP performance appears to rely on the interaction between translucency, restoration thickness, and application technique.

Among all groups and bevel designs, Estellite demonstrated the highest CAP. This superior performance may be attributed to the presence of pigments within its formulation, which enhances its ability to modulate color and harmonize with the surrounding tooth structure. The incorporation of pigments can improve the blending effect by promoting better light scattering and shade matching in composite resins.

Enamel beveling is a widely accepted procedure in adhesive dentistry to optimize the clinical performance of direct composite restorations.[10] In modern restorative dentistry, its purpose extends to esthetics, as beveling provides a gradual transition between restoration and tooth, improving integration.[9] Beveling removes the aprismatic, fluoride-rich enamel layer, creating a more favorable etching pattern and increasing surface wettability.[10] Exposure of enamel rod ends increases bonding area, promoting stronger micromechanical retention and smoother margins. Studies have demonstrated that beveling improves marginal sealing, reduces microleakage, and enhances the optical transition between composite and enamel.[9,10] Qadir *et al*.[11] also found that a 45° bevel provided better stress distribution and reduced marginal fractures compared with chamfer designs. Beveling therefore softens restoration margins and improves the natural appearance of anterior restorations.[26]

A significant bevel-related increase in CAP-I was observed only for Omnichroma, while Vitra, Charisma Topaz One, and Estellite were unaffected. Accordingly, H0₁—which stated that bevel preparation would not influence CAP-I—was rejected. This material-specific response may be linked to Omnichroma's structural-color mechanism, which relies on light-scattering phenomena that could be amplified at beveled enamel margins. In contrast, the remaining materials exhibited stable CAP-I values regardless of beveling, indicating that their blending behavior is largely governed by intrinsic optical properties rather than cavity design.

Moreover, inter-material differences were significant only in non-beveled restorations, whereas beveling diminished these differences, possibly by creating a smoother optical transition at the restoration margins. Therefore, H0₂ was also rejected, as significant material-dependent differences were demonstrated—particularly in non-beveled restorations—highlighting that intrinsic optical characteristics had a more decisive influence on chromatic blending than margin configuration. One-shade composites demonstrated variable CAP performance depending on material type, underscoring the importance of appropriate material selection and application strategy in anterior esthetic restorations. A primary limitation of this study is the use of acrylic resin molds, which, despite offering standardization, lack the complex optical gradients and histological structure of natural tooth tissues. Additionally, the assessment was confined to a single background shade (A2) and immediate optical integration, meaning the results may not fully extrapolate to the entire spectrum of tooth shades or long-term clinical scenarios involving aging and thermocycling. Finally, reliance solely on spectrophotometric analysis excludes the nuances of human visual perception, which remains essential for evaluating clinical esthetic success. Long-term clinical studies are warranted to confirm these findings and to further elucidate the interplay between cavity design and optical behavior in contemporary composites.

CONCLUSION

Within the limitations of this laboratory study, a significant bevel-related increase in CAP-I was observed only for Omnichroma, whereas Vitra APS Unique, Charisma Topaz One, and Estelite Sigma Quick demonstrated no bevel-dependent changes. This finding indicates that the optical behavior of tested composites with color adjustment feature is material-specific, and that beveling enhances blending performance only in selected formulations.

Furthermore, inter-material differences were evident in non-beveled restorations but diminished when a

bevel was present, suggesting that cavity design may partially mask material-dependent optical variability. Overall, the results indicate that intrinsic optical properties played a more decisive role than bevel preparation in achieving chromatic integration.

These findings suggest that acceptable esthetic outcomes may be achievable without bevel preparation when using contemporary resin composites systems with color adjustment feature, although material selection remains a critical factor. Further clinical investigations are warranted to validate these results under intraoral conditions and to assess the long-term color stability of these composites in functional environments.

CONFLICTS OF INTEREST STATEMENT

The authors report no conflicts of interest to declare.

Bizotaj Uygulamasının Tek Renk Kompozitlerde Renk Uyumu Potansiyeline Etkisi

ÖZET

Amaç: Bu çalışmanın amacı, anterior restorasyonlarda kullanılan üç tek renkli ve bir adet geleneksel rezin kompozitin renk uyumu potansiyeli (CAP) üzerine bizotaj preparasyonunun etkisini değerlendirmektir.

Gereç ve Yöntemler: Çalışmada üç tek renkli (Omnichroma, Vitra APS Unique, Charisma Topaz One ve bir adet geleneksel (Estellite Sigma Quick) incelendi. A2 renkli akrilik kalıplarda 6 mm çapında, 2 mm derinliğinde, bizotajsız veya 2 mm, 45° bizotaj uygulanmış kaviteler hazırlandı. Her grup 10 örnekten oluştu (n=10). Restorasyonlar tek tabaka halinde yerleştirildi, ışıkla polimerize edildi, polisajı yapıldı ve 24 saat distile suda bekletildi. Renk parametreleri (L*, a*, b*) spektrofotometre (VITA Easyshade V) ile ölçüldü; ΔE değerleri CIEDE2000 formülüne göre hesaplandı. Renk uyumu potansiyel indeksi (CAP-I)=1−(ΔEDUAL/ΔESINGLE) olarak belirlendi. Veriler ANOVA , t-Test ve Tamhane post-hoc testleri ile analiz edildi (α=0.05).

Bulgular: CAP-I değerleri bizotajsız gruplarda 0.57–0.86, bizotaj uygulanan gruplarda 0.85–0.94 arasında değişti. Bizotajlı tasarım ile bizotajsız kaviteler arasında anlamlı fark Omnichroma grupları dışında bulunmadı (p=0.003). Omnichroma bizotajsız grupta en düşük, Estellite ise genel olarak en yüksek CAP değerini gösterdi.

Sonuç: Bizotaj preparasyonu test edilen rezin kompozitlerin renk uyumu potansiyelini anlamlı şekilde etkilememiştir. Estetik entegrasyonda kavite tasarımından çok restoratif materyalin optik özellikleri belirleyici görünmektedir. Bu nedenle, uygun kompozit seçimi anterior_restorasyonlarda doğal görünüm elde edilmesi açısından kritik öneme sahiptir.

Anahtar Kelimeler: Diş kavite preparasyonu; Kompozit dental rezin; Renk

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