

Review Article

A review on the compatibility of shade systems for composite resins and ceramics

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ABSTRACT:

Aesthetic dental restorations represent a substantial component of restorative, prosthodontic, and pedodontic dental practice. Composite resin restorations are clinically convenient but lack long-term durability in the oral cavity. Their capacity to replicate real teeth in comparison to dental ceramics is likewise contentious. Porcelain restorations may be customized in various hues of body, dentin, and enamel to resemble real teeth. Manufacturers have introduced multilayered composites as an alternative to dental porcelain restorations, asserting that they provide a range of hues from the VITA 3D master shade guide. This research review is intended to uncover recent evidence contributing to the shade selection process, the kinds of new shade guides, their advancements in composite shade guide systems, and the present condition of shade mismatch. Literature was examined in four prominent medical and dentistry databases from January 2010 to June 2024. Most researches related to multilayered or multishaded dental composites proclaim the shades to match various shades of VITA three D master, while many show evidence that they do not match.

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INTRODUCTION

The presence of anterior teeth and their relative visibility during normal speech and smiling influence facial esthetics.¹ Besides their colour, their alignment with the facial midline, symmetric distribution within dentition, phonetics and psychological influence also contributes as scientifically correlated factors.^{2,3} The facial features also serve as a guideline to allow restorations to be placed in harmony with various aesthetic distributions of the face. Vertical dimensions of the face not only contribute to comfort but also impair facial esthetics.⁴ All restorative procedures can formulate restorations either directly in the patient's mouth or outside in the dental laboratory.⁵ For either type, shade matching is an essential clinical step that not only requires understanding of aesthetics and material sciences but also, with time, requires clinical

experience.⁶ Most of the satisfactory restorations have failed despite being the most indicated tooth-matching restorations at the time of diagnosis and treatment planning.⁷ Shade matching is difficult, especially with highly discoloured tooth structures or 'through and through' Class III and IV restorations, when little or no tooth structure surrounds the restoration to reflect or transmit colour.⁸ A dentist may be pleased with a shade guidance decision, but the actual restoration may not match as intended, particularly after finishing and polishing.⁸ Modern dentistry requires the ability to employ dental materials, especially composite resins, to provide the greatest aesthetic outcome. Composite resins have been an integral part of restorative dentistry across all dental disciplines and are considered a highly aesthetic substitute for natural tooth structure. They

are generally directly placed in the oral cavity, although indirect composites are also available. Dental technicians may indirectly make composite restorations for improved proximal margins and contouring.⁹ Here, color communication with the dental lab is crucial. Since the tooth crown includes several colored layers, it appears impossible to duplicate these structures using dental materials with diverse colors and translucency.¹⁰ Replacements of composite resin restorations primarily occur due to an unacceptable color match.^{11,12}

Factors Affecting Shades: The human eye can distinguish subtle colour changes but struggles to match things especially when a restoration is backed by a metal framework.¹³ In addition to colour, geometric variables like surface roughness, gloss, haze, and translucency (contrast ratio, hiding power, masking ability, opacity) affect restoration look.^{12,14} Multifactorial composite resin discolouration includes internal and extrinsic staining. Colour stability and conversion rate are correlated, with partially polymerised composite resins having lower mechanical qualities like hardness and higher discolouration susceptibility.¹⁵ The backdrop and thickness of composite resins might affect the outcome. Translucency is also impacted by composite resin thickness especially those observed in bulk fill composites.¹⁵ Chemical reactivity, energy exposure, water sorption and surface smoothness affect composite resin discolouration.^{10,12} Aesthetic composite resins may discolour due to external and intrinsic causes after extended oral staining like the ones seen with consumption of beverages and exposure to smoke.^{12,14} Thus, composite resin colour stability is crucial when choosing a resin product to meet a patient's aesthetic demands.⁸ An optimal colour match depends on many subtle factors, including accurate shade selection methods (visual or systematic), accurate tooth colour representation by a shade guide, consistency of shade designations within and between material brands, and precise communication of these findings.^{12,13} Shade guides not accurately representing tooth colour, spectrophotometers, colorimeters, visual shade matching, and similar shade designations between composite brands have all been implicated.^{12,14} The surface finish of tooth-colored restorative materials affects their appearance and durability.¹² Surface modifications during finishing and polishing affected dental composite resin optical characteristics like translucency and opalescence.¹⁶ Polished composite resins are lighter, whiter, and less shiny than matrix-covered surfaces.¹⁷ Tooth tissues (pulp, dentin, and enamel) have varied optical properties, and their thickness, calcification, composition, and translucency determine the crown's polychromatic look.^{12,18} Varying dental groups and crown preparation sections have varying dentin and enamel thicknesses affecting their individual color parameters of hue,

value and chroma.^{19,20} Aesthetic outcomes and objectives also vary according to type of restoration (crown, fixed partial denture) and the underlying foundation restoration (post core, pin amalgam restoration).²¹⁻²⁴

Dental Shade Guides And Tabs: Dental shade recommendations match the colour of tissues dentists replace, including teeth, gingiva, and facial tissues like skin, mucosa, and eyes.^{2,4,6,16} As a rule, dental structure shade guidelines should include all natural dentition hues. They must be rationally organised and include easy-to-use tabs. Shade guidelines are the sole dental office-laboratory communication method. Dental shade guidelines are made using conventional or custom-made colour standards that match dental anatomy.^{8,25} Colour matches with real teeth are visually assessed and standardized after observing biological responses.²⁶ Shade guides may be created individually or prefabricated.^{12,27} Another categorisation method is based on their material: ceramic, composite resin, or acrylic. Shade guidelines may be employed for tooth or gingival colour matching or maxillofacial prostheses, depending on the structures of interest.²⁸ Patients interests and their relative differences with dentist or other individuals should also be kept in mind.^{29,30} Each shade tab contains incisal, middle, and cervical parts with different colour density and translucency.³¹ A porcelain repair shade guide subsequently inspired development of Vita 3D Master shade guide.³² Many dental material producers provide shade guidance tabs in different sizes and shades.¹² These increase variety but confound dentists in terms of their choices.³² Most dentists choose colour by visual comparison using shade recommendations. It is subjective yet exact depending on the clinician's experience.³³ Many composite manufacturers don't make shade recommendations for direct repairs. Instead, most utilise the Vita Classical Shade Guide for determination of their manufactured composite shades.^{12,34} The lack of resin composite shade nomenclature is one of the fundamental issues in composite resin shade matching.³⁵ Composite manufacturers may call their shades similarly to the Vita Classical Shade Guide, but they may not match.³⁶ The shade guidelines and resin composite mismatch bothered 58% of dental educators in one of the study.³⁷ This mismatch may be due to the shade guide's different composition and thickness from the composite repair.³⁸ Thus, direct restoration colour selection and matching are considerably harder.³⁹ With 16 enamel and dentine hues, Vita Classical is the most traditional shade guide after 50 years.⁴⁰ In patients' opinions, restorative shade was most critical. Visual examination using a shade guide or instrumental measurement may evaluate tooth shade.⁴¹ Most commercial shade recommendations don't match real tooth colour.⁴² The likelihood of error in shade selection is high due to the need to

approximate tooth colors to the nearest shade of the guide. Individual shades in shade guides affect measurement reliability and validity. The visual perception of color is influenced by ratios for value and chroma. Matching the gingival one-third to one-half of the tooth involves comparing incisal segments. Maintaining the right thickness range is crucial for achieving a desirable shade. For all ceramic restoration shades, even shade of the resin cement becomes critical, and with composite restoration the amount and type of underlying tooth structure is more influential.⁴³

Vita Shade Guides: In 1976-1978, CIE created a new colour system called CIE Lab, which classified shades mathematically.⁴⁴ This allowed for easy and accurate color definition using numeric representation. The first clinical implications of this system were the development of the VITA 3D Master shade guide. Vita Classical was divided into four groups based on the dominant HUE (color name), with 16 tabs.⁴⁵ The Vita Lumin Vacuum shade guide was divided into four series with brown, yellow, gray, and red hues.⁴⁶ The Vita 3D-Master shade guide was further developed to extend chromaticity ranges and improve intrarater repeatability for general practitioners. It features a systematic colorimetric distribution of 26 shade tabs within the tooth color space, organized into 5 primary value levels and a secondary distribution based on chroma and hue. Three additional tabs were added for bleached teeth, denoting the value of 0, three levels of Chroma, and mean colour tone (M).³⁷

Composite Shade Guides: Manufacturers claim that their composite resin or acrylic materials correspond to ceramic color standards, but they often provide specific shade guides with their materials. These shade tabs can be one or multiple layers and may be supplied with "protocols" for mixing different enamel and dentin masses. Disinfecting solutions, heat, polishing, and storage time can greatly affect the quality of these shade guides.⁴⁷ In individually fabricated shade guides, it is not always possible to determine the color match between natural dentition and commercially available shade guides.⁴⁸ Most manufacturers cross-reference their shades with the VITA shade guide, which can lead to errors in shade selection due to the range of shades in shade guides not being consistent with natural teeth. Shade guides are not fabricated to match natural teeth and do not match other shade guides, leading to coverage error.⁴⁹ Custom shade guides made of composite are considerably more accurate, but they are not always practical. Some manufacturers provide prefabricated moulds to facilitate the fabrication of custom guides, but this process can be time-consuming and material-intensive.^{12,50} A study found that the tested gingiva-colored shade guide (composite resin) had different CEs under illuminant D65 than under illuminant A

and exhibited metamerism.⁵¹ The fluorescence of 0.5 mm thickness of all composites was higher than that of 1 mm thickness, and the fluorescence of Aelite Enamel was higher than that of Aelite Body irrespective of their thickness.⁵² In conclusion, the color perception and matching of resin composite shades are affected by various factors, including the thickness of shade tabs produced by different manufacturers. The thickness of the tooth preparation in a crown or a bridge restoration, plays an important role for dental ceramics.⁵³

Composite Advances: Advances in filler loading, type, and size have improved the appearance of composite resin restorations. Nanofilled composites, with filler particles between 5 and 100 nm, provide favourable translucency, polishability, and surface-gloss retention.⁵⁴ Conventional hybrid composites often contain filler particles with a mismatch in refractive index, reducing translucency. UDMA is more resistant to staining than Bis-GMA due to its low sorption and water solubility characteristics.^{5,18} Filtek Supreme, a new composite resin, has a higher amount of TEGDMA, which only contains Bis-GMA, leading to higher water absorption and greater staining.^{26,38} However, there are few studies on nanoparticled composite resins, suggesting further research. Imperceptible composite resin restorations can be achieved through natural incremental layering with various shades of enamel and dentine-like materials.⁵⁵

Reasons For Shade Mismatch: Ikeda et al. found that opaque-shade composite resins are less translucent than dentin or enamel shade composite resins, and 2 mm thick is preferable for shade matching.⁵⁶ The addition of Bis-GMA to TEGDMA increases the resin's refractive index, enhancing its optical match with the silica filler system. The color of a translucent composite material is influenced by the material's basic optical properties, thickness, and backing color.⁵⁷ The inherent color and translucency depend on the colorants incorporated in the matrix, with the filler particles and their interaction having a significant effect.⁵⁸ In dental resin composites, the organic matrix absorbs some light and is considered a weak scattering component. Formulating a composite with translucency that doesn't change on curing can improve composite shade-matching. The study focuses on the color changes in resin composite samples, specifically the shade guide tabs, which are curved resembling natural dentition.⁵⁹ Flat samples do not reflect light the same way as curved ones, and fabricating curved samples results in uniform specimen thicknesses.⁶⁰ The shade guide teeth were painted with white barium sulfate, which may explain the high L values compared to the two brands for all of the 5 shades studied.⁶¹ The color distribution of shade guides varied by the illuminant, and the range of color difference for shade tabs by the illuminant

was 0.80 to 4.82, which may be clinically unacceptable. Instrumental color measurements of shade guides are variable due to several reasons, including the uneven distribution of shade guides, variations between batches, and inherent difficulties with instrumental measurements of tooth materials.⁶² During polymerization, carbon-carbon double bonds are broken to create carbon-carbon single bonds, forming polymer networks.⁶³ This process causes the activated photoinitiator to lose its yellowness and become invisible, causing changes in the initial CIE b* (yellowness) value. The color stability of dental materials is influenced by the degree of water sorption and hydrophilicity of the resin matrix.⁶⁴ Water can dilute pigments in restorative dental composite materials, and they are more susceptible to chemical degradation in the oral cavity due to diets containing colored and acidic food and drinks.

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