



Spectrophotometric Evaluation of Color Matching between Acrylic Resin-Based Artificial Teeth and Conventional Shade Guides: An *in Vitro* Comparative Study

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Abstract

Introduction: Accurate shade selection is essential for achieving aesthetic harmony in prosthetic restorations. However, discrepancies often arise when matching commercial prosthetic teeth with standardized shade guides. This study aimed to evaluate the chromatic compatibility between commercially available prosthetic teeth and two types of shade guides: the conventional Vita Classic[®] and manufacturer-specific shade guides. **Methods:** An *in vitro* comparative study was conducted on 13 brands of prosthetic teeth widely distributed in the Moroccan market. Color assessment was limited to shades A1, A2, and A3, based on their high prevalence in the local population. Color measurements were performed using the Spectroshade[®] spectrophotometer and analyzed in the CIE Lab* color space. Delta-E values were calculated to quantify the chromatic deviation between the commercial teeth and the reference shade tabs. The threshold of visual perceptibility was set at $\Delta E = 3.7$. **Results:** Significant chromatic discrepancies were found between most commercial prosthetic teeth and the Vita Classic[®] shade tabs, with average Delta-E values exceeding the perceptual threshold. Only the Ivoclar[®] (original) brand showed consistent matching with its own shade guide across all tested shades. The Acry Lux[®] brand demonstrated acceptable results for select shades. Additionally, no direct correlation was observed between the number of resin layers and color matching precision. **Conclusion:** This study highlights the limitations of using universal shade guides such as Vita Classic[®] for selecting commercial prosthetic teeth. Manufacturer-specific shade guides, particularly those provided by Ivoclar[®] and Acry Lux[®], showed greater chromatic accuracy. Clinicians are encouraged to prioritize shade selection based on the actual prosthetic teeth to be

used and to employ digital shade matching tools to minimize subjective variability and improve aesthetic outcomes.

Subject Areas

Dentistry, Prosthodontics

Keywords

Color Matching, Shade Guide, Prosthetic Teeth, Acrylic Resin-Based Artificial Teeth, Resin Layer

1. Introduction

Shade selection and reproduction remain among the most technique-sensitive procedures in prosthodontics. Achieving an acceptable color match is influenced by multiple variables, including observer perception, lighting conditions, surrounding colors, and the intrinsic optical properties of restorative materials. Although visual shade matching is widely practiced, it is inherently subjective and has been shown to present considerable variability, even among experienced clinicians [1]-[3].

Acrylic resin-based artificial teeth are routinely used in complete dentures, removable partial dentures, overdentures, and fixed detachable hybrid prostheses. In conventional complete denture therapy, shade selection is often performed within a single material category, which may reduce matching complexity. However, significant esthetic challenges arise in mixed rehabilitations where acrylic artificial teeth must harmonize with ceramic restorations. In such situations, precise chromatic correspondence becomes critical. This difficulty is largely explained by fundamental differences in optical behavior between polymer-based materials and ceramics, including light scattering, translucency gradients, and pigment integration [4].

Despite these limitations, universal shade guides—particularly the Vita Classic® system—are commonly used in daily practice as reference tools for artificial tooth selection. However, these shade guides were primarily developed for ceramic-based workflows and may not be calibrated to correspond to acrylic resin artificial teeth manufactured using different pigments, fillers, and layering technologies. Consequently, reliance on ceramic-oriented shade guides may lead to clinically perceptible mismatches when applied to acrylic teeth.

In addition, the interpretation of color differences in dentistry should rely on objective numeric parameters, particularly ΔE values, which are widely reported for dental materials and commonly used in denture tooth color studies. These metrics enable a standardized quantification of perceptible and clinically acceptable differences. In this context, Paravina *et al.* proposed clinically relevant perceptibility and acceptability thresholds, providing a practical framework for translating instrumental color differences into clinical decision-making [5].

Another contemporary investigation demonstrated that acceptability thresholds vary significantly depending on chromatic regions of the dental color space, indicating that observer tolerance is not uniform across lightness and chroma combinations [6]. These findings highlight the need for context-specific interpretation of color differences in dentistry.

Parallel to these developments, the growing integration of instrumental shade assessment reflects the need for greater reproducibility and reduced operator-dependent variability. Recent systematic and scoping reviews have shown that digital shade matching methods, including spectrophotometry, generally provide improved repeatability and reliability compared with purely visual approaches, particularly under standardized conditions [7] [8].

Given the widespread clinical use of acrylic resin artificial teeth and the routine reliance on universal shade guides, it remains essential to determine whether true chromatic correspondence exists between these materials and commonly used shade guide systems.

The aim of the present *in vitro* study was therefore to evaluate the chromatic properties of commercially available acrylic resin-based artificial teeth on the Moroccan market and to compare them with the Vita Classic® shade guide tabs and manufacturer-specific shade guides, using spectrophotometric measurements expressed in the CIE Lab* color space.

2. Materials and Methods

2.1. Study Design

An *in vitro* comparative study was conducted to evaluate the chromatic correspondence between acrylic resin-based artificial teeth and commonly used shade guide systems. Thirteen commercial brands officially available on the Moroccan market were included.

For each brand, three shades (A1, A2, and A3) were selected, corresponding to the most frequently used reddish-brownish shades in clinical practice. The analysis was restricted to the “A” shade group due to its predominance within the Moroccan population.

The study was restricted to A1-A3 shades because these represent the most frequently used range in removable prosthodontics. Therefore, findings apply only to these tested shades.

Only five manufacturers provided proprietary shade guides for their artificial teeth; these were included for brand-specific comparisons.

Artificial teeth were categorized according to their manufacturing structure into single-layer, bi-layer, and tri-layer systems. One artificial tooth per shade and per brand was analyzed.

For standardization, only maxillary central incisors of comparable mold and size were selected whenever available. All specimens were obtained from unopened commercial boxes from the same batch when possible. Products were considered officially available if distributed through authorized dental suppliers in

Morocco.

This investigation was designed as an exploratory pilot study.

2.2. Color Measurement Protocol

Color measurements were performed using an electronic spectrophotometer (SpectroShade[®], MHT, Italy). Each specimen was positioned consistently, and three consecutive readings were obtained under standardized conditions. These repeated measurements were considered technical replicates intended to improve instrumental repeatability.

Measurements were performed on the middle third of the labial surface against a neutral gray background. The spectrophotometer was calibrated before each measurement session according to the manufacturer instructions. Specimens were cleaned with distilled water and dried before measurement. Each specimen was repositioned between readings to minimize orientation bias.

Mean L*, a*, and b* values were calculated for each tooth and recorded in an Excel[®] database.

Chromatic data were expressed in the CIE Lab* color space. Color differences (ΔE) between artificial tooth shades and corresponding shade guide tabs were calculated using the CIE ΔE_{ab} formula, which quantifies chromatic differences between two points in the CIE Lab system.

2.3. Visual Tolerance Threshold

The ΔE_{ab} threshold of 3.7 was selected based on classical perceptibility limits widely reported in dental color literature and used as a clinical perceptibility threshold throughout the manuscript [9].

In dentistry, a ΔE value of approximately 3.7 is commonly accepted as the visual perceptibility threshold. Color differences exceeding this value are considered clinically noticeable, whereas values below this threshold generally correspond to an acceptable visual match.

2.4. Data Processing and Comparative Analysis

Chromatic data were analyzed according to the following protocol: grouping by resin layer count; ΔE computation vs Vita Classic[®]; ΔE computation vs manufacturer shade guides (when available); comparison of manufacturer shade guides vs Vita Classic[®]; conversion of manufacturer guide Lab* to Vita Classic[®] and Vita 3D Master[®] equivalents; evaluation of chromatic behavior as a function of layering.

2.5. Inclusion and Exclusion Criteria

Thirteen brands of acrylic resin-based artificial teeth officially marketed in Morocco were included in the study (Table 1). Two ranges identified on the local market but not formally distributed through authorized channels (Cosmo XXL[®] and Integral Business[®]) were excluded.

Table 1. Study sample.

Artificial teeth brand	Number of layers	Shades	Corresponding Shade Guide
Ivoclar Ivoben (Benident)	3	A1, A2, A3	Ivoclar Ivoben (Benident)
New Acry Lux (Ruthinium)	3	A1, A2, A3	New Acry Lux (Ruthinium)
Ivoclar Original (Vivadent)	3	A1, A2, A3	Ivoclar Original (Vivadent)
Counterfeit Ivoclar (Vivadent)	3	A1, A2, A3	Counterfeit Ivoclar (Vivadent)
Acry Lux (Ruthinium)	3	A1, A2, A3	Acry Lux (Ruthinium)
Unident	2	A1, A2, A3	Unident
Biodent	2	A1, A2, A3	Biodent
New Acry Dent	2	A1, A2, A3	New Acry Dent
Acry Rock (Ruthinium)	2	A1, A2, A3	Acry Rock (Ruthinium)
Maxident	1	A1, A2, A3	Maxident
Artdent	1	A1, A2, A3	Artdent
Maxident Plus	1	A1, A2, A3	Maxident Plus
Alpha Lux	1	A1, A2, A3	Alpha Lux

3. Results

3.1. Chromatic Correspondence between Artificial Teeth and Vita Classic® Shade Guide

Across all tested brands and shades, acrylic resin artificial teeth generally exhibited ΔE values exceeding the visual perceptibility threshold of 3.7 when compared with the corresponding Vita Classic® shade guide tabs.

Mean ΔE values according to resin layering are presented in **Table 2**. Tri-layer systems demonstrated mean ΔE values of 6.08 ± 0.78 (A1), 5.00 ± 2.03 (A2), and 4.35 ± 1.59 (A3). Bi-layer teeth showed mean ΔE values of 5.15 ± 1.93 (A1), 4.77 ± 1.68 (A2), and 4.77 ± 1.71 (A3). Single-layer teeth presented mean ΔE values of 5.67 ± 0.56 (A1), 4.12 ± 0.56 (A2), and 5.53 ± 0.26 (A3). Although isolated measurements approached or fell below the perceptibility threshold, all resin configurations exhibited mean ΔE values above 3.7 across A1-A3 shades, indicating clinically detectable color discrepancies regardless of layering.

Table 2. ΔE values (Mean \pm SD) between artificial teeth and Vita Classic® shade guide tabs according to resin layering.

Resin Layer	A1 (Mean \pm SD)	A2 (Mean \pm SD)	A3 (Mean \pm SD)
Tri-layer (n = 5)	6.08 ± 0.78	5.00 ± 2.03	4.35 ± 1.59
Bi-layer (n = 4)	5.15 ± 1.93	4.77 ± 1.68	4.77 ± 1.71
Single-layer (n = 4)	5.67 ± 0.56	4.12 ± 0.56	5.53 ± 0.26

3.2. Brand-Specific Comparison with Vita Classic®

Individual ΔE values by brand and shade are summarized in **Table 3**. Only six isolated measurements across all brands fell below the perceptibility threshold. Ivoclar Viva 2 exhibited the lowest ΔE values for A2 and A3, while Acry Rock

showed acceptable correspondence only for A1. Most brands demonstrated ΔE values well above 3.7 for at least two shades.

Table 3. ΔE values between individual brands and Vita Classic®.

Brand	Layers	A1	A2	A3
Ivoclar Ivoben	3	6.28	6.50	5.03
New Acry Lux	3	6.20	5.45	5.10
Ivoclar Viva 1	3	5.20	3.20	5.10
Ivoclar Viva 2	3	7.20	2.60	1.50
Acry Lux	3	5.50	7.25	5.00
Unident	2	5.22	6.91	2.43
Biodent	2	4.89	3.10	6.55
New Acry Dent	2	7.60	3.81	5.10
Acry Rock	2	2.90	5.24	5.00
Maxident	1	6.49	3.58	5.42
Artident	1	5.48	4.00	5.74
Maxident Plus	1	5.47	4.00	5.74
Alpha Lux	1	5.25	4.90	5.22

3.3. Equivalent Shade Mapping to Vita Classic® and Vita 3D Master®

Equivalent shade mapping was performed by calculating the color difference between each artificial tooth and all reference shade tabs. Each specimen was assigned to the closest shade based on minimum ΔE value.

Conversion of artificial tooth CIE Lab* coordinates into Vita Classic® and Vita 3D Master® equivalents revealed marked dispersion (**Table 4**). Artificial teeth labeled A1–A3 frequently corresponded to alternative Vita Classic® designations (B1, B2, C2, D4, A3.5) and heterogeneous Vita 3D Master® values, demonstrating the absence of direct chromatic equivalence between manufacturer labeling and standardized ceramic shade systems.

Table 4. Representative shade mapping from artificial teeth to Vita systems.

Brand	Labeled Shade	Vita Classic®	Vita 3D Master®
Ivoclar Ivoben	A1	B1	1M1
Ivoclar Ivoben	A2	D2	2L1.5
Ivoclar Ivoben	A3	D4	3L1.5
New Acry Lux	A1	B2	2L1.5
Acry Rock	A1	B1	2M1
Alpha Lux	A3	B4	3L2.5

3.4. Comparison with Manufacturer-Specific Shade Guides

Comparison between artificial teeth and their respective shade guides showed var-

iable internal calibration (**Table 5**). The original Ivoclar[®] system demonstrated ΔE values below the perceptibility threshold for all tested shades, whereas counterfeit Ivoclar products exhibited pronounced discrepancies. Partial agreement was observed for Acry Lux[®] and Biodent[®], while Acry Rock[®] showed acceptable correspondence only for A3.

Table 5. ΔE values between artificial teeth and manufacturer-specific shade guides.

Brand	A1	A2	A3	Interpretation
Ivoclar Original	1.94	1.44	3.29	Acceptable
Counterfeit Ivoclar	4.21	5.40	6.80	Poor
Acry Rock	6.61	5.33	3.52	Partial
Acry Lux	3.90	4.89	2.72	Moderate
Biodent	3.94	5.96	4.00	Poor

3.5. Manufacturer Shade Guides Versus Vita Classic[®]

Direct comparison between manufacturer shade guides and Vita Classic[®] revealed limited chromatic interoperability (**Table 6**). Only the Acry Lux Tint Maker demonstrated ΔE values below or close to 3.7 for all shades, while Biodent Tint showed acceptable correspondence only for A1.

Table 6. ΔE values between manufacturer shade guides and Vita Classic[®].

Shade Guide Brand	A1	A2	A3	Overall Assessment
Ivoclar Shade Maker	4.2	4.1	4.5	Poor
Acry Rock Shader	7.3	6.1	5.3	Very poor
Acry Lux Tint Maker	2.9	2.9	3.4	Acceptable
Biodent Tint	2.9	4.8	6.2	Partial

3.6. Influence of Resin Layering and Saturation

Table 7. Mean ΔE according to shade saturation.

Layers	A1	A2	A3
Tri-layer	6.06	4.94	4.34
Bi-layer	5.10	4.76	4.77
Single-layer	5.60	4.12	5.53

Tri-layer systems showed slightly lower ΔE values for A3; however, all groups remained above the perceptibility threshold. (See **Table 7**)

4. Discussion

The results of this study show that Vita Classic[®] shade guide tabs are not a reliable method to match the color of acrylic resin denture teeth. This matches what other researchers have found: even within a single commercial shade guide system, the

actual color values (Lab*) can vary from one guide to another [10]. That means using just one guide as a “gold standard” can create mismatches that aren’t actually there.

Beyond the variability of the guides themselves, there’s a bigger issue: do any shade guide systems really match natural teeth? Large spectrophotometric studies comparing human teeth to Vita Classical and Vita 3D-Master systems have shown that these shade guides don’t always represent the full range of natural tooth colors found in real people, and that the mapping between different shade systems isn’t perfect [11]. This supports our finding (Table 3) that the common “A1-A3” labels on artificial teeth often don’t line up with the actual Vita shades.

From a methodological perspective, using a spectrophotometer in this study follows the current best practices, as instrument-based shade assessment has been shown to be more reliable than visual selection [7] [8] [12] [13]. This is especially important when working on complex cases where acrylic denture teeth need to match ceramic restorations.

When we looked at the effect of layering, we found that simply increasing the number of resin layers doesn’t guarantee a better match to Vita Classic®. That makes sense, since the final color depends on many factors—like how the resin is formulated, how pigments are distributed, the degree of translucency, and the surface finish [14]. Studies show that color and optical properties can vary widely among denture teeth brands and materials, and that things like aging or exposure to staining drinks can change the color further [15] [16].

A new challenge comes from digitally fabricated teeth, like those made by milling or 3D printing with PMMA. Recent research suggests that how these teeth are made, and what materials are used, can affect their color stability and how they wear over time [14]. These studies have also reported significant inter-brand chromatic variability in PMMA-based artificial teeth [14]-[16].

This means that, for best results, it’s better to pick the denture tooth brand and shade first (using its own calibrated guide and checking with a spectrophotometer), then match any other restorations to that choice, rather than assuming all shade guides are interchangeable.

This study has several limitations. Only one specimen per brand and shade was analyzed. Measurements were limited to technical replicates. Aging procedures and clinical lighting variability were not simulated. Results should therefore be interpreted as exploratory pilot data.

5. Conclusions

This study found that there are significant color mismatches between most acrylic resin artificial teeth commercially available in Morocco and the Vita Classic® shade guide. Most manufacturer-specific guides also didn’t consistently match their own artificial teeth. The main exceptions were the Ivoclar® system, which showed strong internal consistency, and the Acrylux® range, which performed relatively well. These findings apply specifically to A1-A3 shades and should not

be generalized to other chromatic groups.

Importantly, neither the number of resin layers nor the manufacturing technology predicted how closely a tooth would match a shade guide. This suggests that the most important factor is the manufacturer's color quality control and how materials, pigments, and processing are handled.

From a clinical perspective, these findings suggest several practical steps. When planning mixed prosthetic cases, it's wise to prioritize systems that have demonstrated better chromatic consistency (like Ivoclar[®] and Acrylux[®]). It's also strongly recommended to use the manufacturer's own shade guide, rather than relying on universal guides meant for ceramics. Another good approach is to select the artificial teeth first, then try to match ceramic restorations to them, rather than the other way around. Lastly, using digital shade recording in daily clinical practice can greatly improve precision and help minimize mistakes that come from traditional visual shade selection [7] [8] [12] [13].

Conflicts of Interest

The authors declare no commercial interest in any evaluated brand.

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