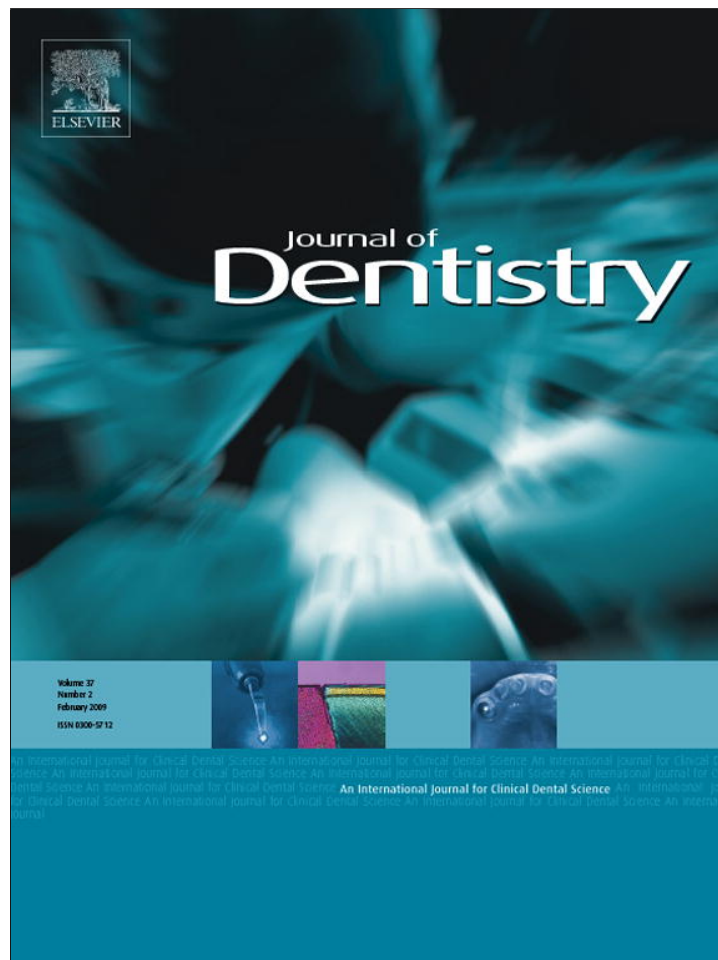




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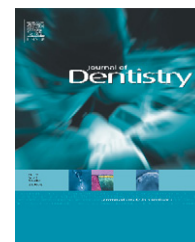
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Colour correspondence of a ceramic system in two different shade guides

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ABSTRACT

Objectives: The aim of this study was to test by means of a clinical spectrophotometer the ability of a ceramic system to correctly reproduce the selected shade with reference to two available shade guides.

Methods: One shade for each guide of Vita Omega 900 ceramic system (Vita Zahnfabrik, Germany) was selected: A3 for the system based on Vitapan Classical; 2M3 for the system based on Vitapan 3D Master. Fifteen discs were fabricated for each ceramic using a proprietary steel mould that allowed to control the thickness of each layer. The total thickness of the specimen was 1.6 mm. The thickness of the metal base disc was 0.3 mm, while opaque was layered in 0.15 mm. Dentin opaque (0.25–0.45 mm), dentin (0.5–0.7 mm), and enamel (0.1–0.3 mm) were then layered following manufacturer's patterns. Each layer thickness was checked after firing. Easyshade (Vita Zahnfabrik, Germany) clinical spectrophotometer was used for colour comparison. "Restoration" mode was selected using A3 and 2M3 shades as comparison. The obtained ΔE values were statistically analyzed with the Two-Way Analysis of Variance and the Tukey Test.

Results: A closer colour correspondence resulted for the ceramic based on Vitapan 3D Master ($\Delta E = 1.80 \pm 0.42$) than for Omega 900 in Vitapan Classical ($\Delta E = 2.94 \pm 0.12$) ($p < 0.001$).

Conclusions: The shade matching ability of the VITA 3D-Master Tooth Guide was found to be more reliable than that of the VITA Classical Shade Guide for Omega 900.

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1. Introduction

The standard clinical procedure to select and reproduce natural teeth colour with ceramic restoration is the visual comparison using a dental shade guide. The first shade guide, introduced in 1929 by Vita, was structured according to an epidemiological distribution of teeth colour observed in nature. The introduction in 1956 of Vita Lumin Vacuum shade guide represented a milestone in the development of a universal standard for tooth colour reference. Notwithstanding its wide clinical success, this shade guide is still based on appearance rather than on a scientific basis. Scientific was

instead the approach for the development in 1998 of the Vita 3D Master shade guide, referenced to Lab* system established in 1976 by the Commission Internationale de l'Eclairage, which provides the international scientific standards for colour measurements. In other words, the Vita 3D Master is founded on a scientific colour distribution, having a systematic coverage of the tooth colour space of natural teeth according to the colourimetric CIE Lab* order principle, rather than on the mere observation of the natural tissue aspects.¹

Although the use of such a shade guide can be considered an advancement, in practice colour selection is still carried and performed by visually comparing shade tabs with the tooth.

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With the objective of minimizing colour mismatch due to visual estimation, clinical dental spectrophotometers have been developed and marketed. Such instruments are based on CIELab* colour system, although they provide measurements in any dental shade system. Their technology allow to convert perception in numbers, thus making colour selection and colour communication in dentistry easier and more reliable.²⁻⁹

Although clinical spectrophotometers are still under evaluation, they have so far provided satisfactory results and have the potential to greatly simplify the first step in the colour matching procedure, i.e. colour selection.

Nevertheless, the following step in the procedure, colour reproduction, still requires attention and possibly a more scientific approach. In this perspective, it would seem useful if also restorative systems could be based on the CIE Lab* colour space, as the 3D Master shade guide and clinical spectrophotometers are.

Vita Omega 900 is currently the only dental ceramic system marketed in Vitapan Classical shade guide as well as in Vitapan 3D Master. For this reason Vita Omega 900 was the object of this study, which was aimed at testing, by means of a clinical spectrophotometer, the ability of the mentioned ceramic system to correctly reproduce the selected shade colour with reference to the Vitapan Classical and 3D Master shade guides.

The formulated null hypothesis was that no significant difference existed between selected colour and restoration colour for the two shade guides.

2. Materials and methods

The stand-alone clinical spectrophotometer Vita Easyshade (Vita Zahnfabrik, Bad Säckingen, Germany) was used to measure colour differences in the ceramic system Vita Omega 900 Metallkeramik (Vita Zahnfabrik).

Fifteen ceramics discs were fabricated with different layering patterns for each shade, keeping constant the specimen total thickness.

Self-curing acrylic resin discs (DuraLay, LOT 052802, Reliance Dental Manufacturing Co., Worth, IL, USA), 0.7 mm in thickness and 15 mm in diameter were made in a cylindrical stainless steel mold. After applying the material into the mold, a glass plate was pressed onto the most superficial layer in order to obtain a flat surface. Great attention was given to avoid bubble formation within the resin.

Once completely cured, the resin sample was extracted from the mold, put in a refractory cast filled with investment (GC Stellavest, GC Europe, Leuven, Belgium), to be placed in a

burnout furnace (Ovomat 7, Manfredi-SAED, Torino, Italy), following the wax elimination technique.

At the end of the burnout cycle, the investment was moved to an induction casting machine (Enterprise, Jelrus, Hicksville, NY, USA), and filled with a base metal alloy (Biomate-C, Silpo, Italy). The obtained disc-shaped specimens were roughened with a sandblaster (Skylab, Tecnogaz, Parma, Italy), using AlO_2 particles of 100 μm diameter.

For ceramic layering, A3 shade for Vitapan Classical and 2M3 shade for Vitapan 3D Master were selected for being the most frequently re-assorted shade in each system according to the manufacturer. Following manufacturer's instructions, a wash opaque layer (A3 Opaque 9003/2M3 Opaque 9307, Vita Zahnfabrik) was applied first and fired in a ceramic oven (Vacumat 500, Vita Zahnfabrik). Then, a second opaque layer was added and fired (OP2 Opaque Paste 352, Vita Zahnfabrik). At this stage the first opaque dentin layer (A3 Opaque Dentine 9033/2M3 Opaque Dentine 9033, Vita Zahnfabrik) was applied in a thickness controlled by the regulated mould, and fired following the firing manufacturer instructions. Then, a second dentin layer was stratified (A3 Dentine 9053/2M3 Dentine 9053, Vita Zahnfabrik), and consequently fired. Subsequently, as indicated in ceramic instructions, the enamel layer was stratified (EN2 Enamel 9072, LOT 7846, Vita Zahnfabrik), and fired in the ceramic oven. At the end, for each sample, a glaze firing was done according to the ceramic manufacturer's instructions.

Each layer was measured by an electronic calliper (1651 DGT, Beta, Milan, Italy) with a 10- μ m resolution. Three distinct layering patterns were realized that differed for the thickness of the opaque dentin, dentin, and enamel layers (Table 1).

2.1. Spectrophotometric measurements

The spectrophotometer Vita Easyshade is composed by a base unit and a hand piece. The colour evaluation was done free hand simulating the clinical use. "Restoration" mode was selected using A3 and 2M3 shades as comparison.

2.2. Statistical analysis

ΔE values calculated by the spectrophotometer according to the formula proposed by Clarke¹⁰ were statistically analyzed. Having preliminarily checked for normality of data distribution (Kolmogorov-Smirnov test) and homogeneity of group variances (Levene test), the Two-Way Analysis of Variance was applied with ΔE values as the dependent variable, shade guide-ceramic system and layering pattern as factors. The Tukey test was applied for post hoc comparisons as needed. In all the analyses the level of significance was set at $p < 0.05$.

Table 1 – Layering patterns of the ceramic specimens.

Sample		LP*	Alloy	Opaque	Opaque dentin	Dentin	Enamel	Final
O900 Cl	O900 3D							
1-5	16-20	1	0.30 mm	0.15 mm	0.25 mm	0.60 mm	0.30 mm	1.30 mm
6-10	21-25	2	0.30 mm	0.15 mm	0.35 mm	0.70 mm	0.10 mm	1.30 mm
11-15	26-30	3	0.30 mm	0.15 mm	0.45 mm	0.50 mm	0.20 mm	1.30 mm

LP* = layering pattern.

3. Results

The Two-Way ANOVA showed that both “shade guide-ceramic system” and “layering pattern” significantly influenced the ΔE values ($p < 0.001$). Particularly, regardless of the layering pattern, the ΔE values of Vita Omega 900 in 3D Master shade guide were significantly lower than those of Vita Omega 900 in Vitapan Classical shade guide (Table 2). The three assessed layering patterns differed significantly among each other, according to the Tukey test for post hoc comparisons. With regard to the significant between-factor interactions, when evaluated at the univariate level they disclosed a similarity in ΔE values for all the layering patterns with Vitapan Classical. Conversely, with Vitapan 3D Master, the ΔE values were lower for the layering pattern 1 than for the 2, whose ΔE values were in turn lower than those of pattern 3 (Table 2). These differences were statistically significant according to the Tukey test for pairwise comparisons.

4. Discussion

Colour matching has always been a basic and primary step in prosthetic and restorative dentistry. Colour is one of the characteristics of a dental restoration that the patient evaluates first. Therefore, colour selection and reproduction represent a challenge to the clinician.¹¹

Vitapan Classical has been considered for many years the reference shade guide among those available for ceramic systems. This role is going to be progressively taken over by Vitapan 3D Master, a relatively new concept of systematic coverage of natural teeth colour space, based on the colourimetric CIE Lab* order principle.¹

In this study, in order to verify whether with this new shade guide the match between tab standards and layered specimen is influenced by the shade guide, specimens made with the only one ceramic system available for use in both shade systems, Vita Omega 900, were compared. Ceramic specimens were prepared according to manufacturer's layering instructions in a standardized 1.3 mm thickness over 0.3 mm thick metal substructure. Clinically, in the tooth preparations for porcelain fused to metal (PFM) restorations, tooth reduction may range between a minimum of 1.2 mm at the cervical third and 1.6 mm at the middle third. At the latter level, 1.2–1.3 mm represents the thickness of opaque and veneering, whereas 0.3–0.4 mm is the thickness required for the metal substructure.

In the occlusal or incisal third the amount of tooth structure to be removed is at least 2.0 mm.^{12,13}

In recent years the scientific study of dental colour has been directed towards minimizing errors in visual colour selection through the use of spectrophotometers.^{7,8,14}

The Vita Easyshade is one of the latest spectrophotometer available for clinical use. In this study the instrument was used with a ceramic system belonging to the same manufacturer.²

The instrument's software is programmed to give absolute CIE Lab* colour values only for natural teeth. Conversely, when assessing the colour of a ceramic, the spectrophotometer provides the differences (Δ values) from colour values presets in the instruments database. The spectrophotometer data acquisition is different when reading natural tooth and ceramic also because the instrument applies different scanning methods on the two diversely structured substrates. Ceramic restorations are generally less than 1.6 mm in thickness and the colour layers (dentin and opaque) are from 0.2–0.4 mm under the enamel porcelain layer. Conversely, inside the teeth, the dentin layer is generally 1.0–1.5 mm from the outer surface. Furthermore, the enamel thickness causes a scattering of the penetrating light. Moreover, the overall thickness of a natural tooth is greater than that of a ceramic tooth.¹⁵

With regard to ceramic assessment, it should be pointed out that the referential colour values in the instrument database can be considered reliable for colour matching because the ceramic systems object of this study and the clinical spectrophotometer used for colour measurements are produced by the same manufacturer.

When assessing the influence of the shade guide by comparing equally layered specimens of Vita Omega 900 in A3 and 2M3 shades, it was evident that the latter exhibited a closer colour correspondence with the colour values set in the spectrophotometer. This result may be explained by the ability of Easyshade to better match colours that are organized in a scientifically based systematic spatial distribution. This colour distribution is the basis of the 3D Master shade guide.^{16,17} As a matter of fact, Omega 900 in 2M3 shade demonstrated a significantly closer colour correspondence than Omega 900 in A3 shade (Table 2). Such a finding leads to rejection of the null hypothesis.

Data in Table 2 demonstrate that the closest colour correspondence with standards was obtained when, regardless of the ceramic system, the n°3 layering pattern was followed. In this pattern equal thicknesses of opaque dentin (0.45 mm) and dentin (0.50 mm) were stratified.

Table 2 – Descriptive statistics of the ΔE values recorded in the experimental groups. In the significance column, different superscript letters label significant differences when the ceramic system*layering pattern interactions were assessed at the univariate level.

Ceramic system	LP	n of specimens	Mean (ΔE)	S.D.	Significance ($p < 0.001$)
Omega 900 Classical	1	5	3.04	0.46	d
	2	5	2.88	0.48	d
	3	5	2.9	0.46	d
Omega 900 3D Master	1	5	2.3	0.47	c
	2	5	1.76	0.49	b
	3	5	1.34	0.47	a

The statistical analysis revealed a significant influence of the layering pattern on colour correspondence (Table 2). It should therefore be of scientific and clinical interest to assess with further research to what extent each layer influences the final colour.

The finding of a closer colour correspondence when referring to 3D Master also suggests the use of ceramic systems based on this shade guide in combination with the clinical spectrophotometer, for the purpose of minimizing errors in the colour matching procedures.

5. Conclusion

Within the limitation of this study, specimens of Vita Omega 900 in Vitapan 3D Master shade guide exhibited for the investigated shade a closer match in colour than specimens of the same ceramic system in Vitapan Classical shade guide. Therefore, the higher colour correspondence can be considered to be shade guide dependant. Further studies are necessary in order to establish the influence of each layer on the final colour of the restorations.

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