

Original Article

Spectrophotometric comparison of two porcelain systems, VMK master and VM13 with the VITA 3D-master shade guide (An *in vitro* study)

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ABSTRACT

Background: Accurate shade matching of metal-ceramic restorations with natural teeth is one of the most challenging aspects of dental restorations and esthetic dentistry. The aim of this study was to evaluate the color parameters of two types of porcelain systems VMK Master and VM13 porcelain with VITA 3D-master shade guide.

Materials and Methods: In this *in vitro* study a total of 56 metal discs (10 mm diameter and 2 mm thickness) were fabricated. Each of the disks was veneered with porcelain (Vita Zahnfabrik, Bad Sackingen, Germany) of the VITA shade. The discs were randomly divided into four groups (2M2 and 3M2 from VM13, 2M2 and 3M2 from VMK master) of 14 ($n = 14$). The spectrophotometer was used for taking color measurements based on the numerical color data of the CIELAB color system. Data analysis was performed by *t*-test ($P < 0.05$).

Results: Comparison of color parameters in different porcelain showed that the type of porcelain caused a significant difference in color parameters (L, a, and b) ($P < 0.05$). The degree of translucency (L^*) or glaze of VMK porcelains was higher than VM13, but the parameters a^* and b^* were higher in VM13 porcelains than VMK ($P < 0.05$). Furthermore, the color difference of two porcelain in 2M2 (1.63 ± 0.84) and 3M2 (1.71 ± 0.96) shades was within the acceptable clinical limit. Considering the total color difference (ΔE), there were no significant differences between the ΔE values produced by any of shades ($P > 0.05$).

Conclusion: In the present study, the spectrophotometric analysis revealed that the porcelain shade type causes a change in the color parameters, but the color difference between two porcelains VMK and VM13 is within the acceptable range of clinical color. Therefore, both porcelain systems with 2M2 and 3M2 shades are suitable for enhancing the results of restorative dentistry.

Key Words: Dental porcelain, shade matching, spectrophotometer, VMK master porcelain, VITA VM13 porcelain

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INTRODUCTION

Metal-ceramic restorations are widely used in dental prosthetics. Metal provides strength and porcelain

fused to metal provides the translucency and beauty of natural teeth. The oxide layer on the surface of

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the metal is a bonding agent to the porcelain, but the metal component, however, has an adverse effect on the beauty of the restoration.^[1,2] Dental ceramics in restorations are essentially oxide-based glass-ceramic systems. Ease of fabrication of complex shapes, sufficient mechanical, and corrosion resistance, and appropriate esthetic appeal are the general features of dental ceramics.^[3,4] The desired color of a ceramic restoration is influenced by ceramic.^[4] Veneering ceramics for metal-ceramic restorations which generally named feldspathic porcelains are usually leucite based. VITA VM13 and VMK Master Porcelain are two types of veneering ceramic for metal substructures.^[5] Potassium feldspar, which is essential for manufacturing the VITA VM13 and VMK Master ceramics, helps to achieve ideal abrasion on the antagonist tooth and chemical stability for the oral system.^[6] These materials have more homogeneous structural features than traditional ceramics and have fine-grain structure.^[6] VM13 ceramic veneering porcelain has outstanding physical properties, handling characteristics, homogeneous distribution of glasses in the fine microstructure, and clinical wear characteristics that mimic those of enamel.^[6] The VM13 has a great grinding and polishing function, and it can create very smooth surfaces which prevent plaque from sticking to the ceramic surface and brings a good sense of cleanliness to the patient.^[5] Moreover, these two materials have properties similar to the dentin of the natural teeth.^[6,7] Inadequacies associated with color matching arise from structural differences exist between metal-ceramic restorations and natural teeth.^[8] This structural difference has led to a difference in the absorption and reflection of the optical wavelengths between the teeth and the restoration.^[9] Similarly, the type of alloys and ceramics used in metal-ceramic restorations affects the color of the restoration.^[4] The most frequently used shade-matching method is the visual method which was determined by the traditional classical shade guide.^[10,11] Several studies have specified that common shade guides do not provide sufficient spectral coverage of the colors present in the teeth.^[11,12] Visual shade matching is subjective, and its consistency is difficult to achieve. Photometric and colorimetric analysis techniques were devised as tools for the objective evaluation of color and for aiding in replica process. The instrumental color measurement could be preferred over visual color determination in fixed prosthodontics because-instrumental readings are objective and more rapid.^[13-15] Photometric

instruments, such as spectrophotometer, measure the color under three numerical values (a, b, and L) under the CIELab, in which L represents the brightness value, and the range is from zero (completely black) to 100 (completely white) and a is related to the red-green axis and b is related to the yellow-blue axis.^[16,17] There are several other studies supporting the accuracy of spectrophotometric method rather than the visual method.^[18-21] Several studies have shown that various factors influencing shade of bonded porcelain including the type of ceramic system, porcelain layer thickness, and porcelain shade type.^[18] Furthermore, in a spectrophotometric study for cobalt-chromium and nickel-chromium alloys with two porcelains (Vita omega and Ceramco II silver), the results showed that the type of porcelain and type of alloys affect the final shade of ceramic restorations.^[8] The aim of this study was to investigate the difference of color matching between VMK Master and VM13 porcelain using the spectrophotometric method. Our null hypothesis was that there was no color difference between VMK Master porcelain and VM13 porcelain.

MATERIALS AND METHODS

In the present laboratory study, two ceramic systems VMK Master porcelain (VITA Zahnfabrik, Germany) and VM13 porcelain (VITA Zahnfabrik, Germany) with the two color (2M2, 3M2) were selected. Fifty-six metal-ceramic discs, 14 for each group of nickel-chromium alloy (VeraBond, Aalba Dent Inc., Fairfield, United States) were prepared with a size of 10 mm × 2 mm. Finally, the differences between the two porcelains were measured using the spectrophotometric (X-Rite Grand Rapids, Michigan, United States) and visual method by VITA 3D-master shade guide (Vita lumina shade guide, Vidnet, Germany).

When the NiCr metal discs were prepared, the ceramic opaque was applied. The thickness of porcelain layer was reduced to 0.02 mm by carbide bur. Dentin ceramic 0.7 mm thick was applied over these discs, sintered, and glazed under vacuum conditions in the VITA Vacumat 6000 M Porcelain Furnace (Vita Zahnfabrik, Bad Sackingen, Germany) according to manufacturer's instructions. To compensate the sintering shrinkage, dentin firing was performed in two stages. Since we wanted to evaluate the color of the dentin, we just used the dentin layer. We want to evaluate at the end of each step, the layer thickness

was evaluated after each firing, and the necessary corrections were made by both grinding and adding porcelain with green molten alumina (Dura-Green Stones, Shofu Inc., China) and diamond milling until 1.5 mm thickness was obtained. All samples were polished with rubber (Dura-Green Stones, Shofu Inc., China). To achieve the desired thickness in all stages, a digital caliper (Mitutoyo, Japan) was used at four environmental points, and a central point and the thickness of the samples reached 2 mm. In addition, an aluminum shablon plate supplied with circles (diameter = 11 mm and thickness = 2 mm) were used for positive control. The thickness of opaque and dentin layers and metal substructure were prepared as follows: the thickness of the alloy = 0.3 mm, the final thickness of the porcelain = 1.7 mm, and the final thickness of the metal-ceramic discs = 2 mm.

Spectrometric analysis

The visual shade evaluation of the samples was determined by five dentists using the VITA shade guide. The determination of the shade samples was performed by substantial cross-observer agreement of three dentists.^[18] Color of dental materials is expressed in “L*,” “a*,” and “b*” coordinates according to the CIELab color space using VITA easy shade spectrophotometer (Vita Zahnfabrik, Bad Säckingen, Germany), under C-L Light source, North Sky Daylight, 10° angulation. Statistical analysis was done by SPSS version 20 (IBM, Chicago, USA). Data analysis was performed *t*-test ($P < 0.05$).

RESULTS

The results of *t*-test showed a significant difference in the values of a*, b*, and L* parameters of 2M2 and 3M2 shades in VMK and VM13 porcelains ($P < 0.05$) [Table 1].

The results of the present study showed that the ΔL parameter of 2M2 was 0.01–3.13 (Mean = 1.37), and in the 3M2 color ΔL parameter was 0.54–2.19 (mean = 1.27). Moreover, the results of statistical analysis showed no significant difference in ΔL of two porcelains ($P > 0.05$) [Table 2].

Finally, the results of this study showed that the color difference (ΔE) of two porcelains VMK and VM13 in 3M2 color was more than 2M2. The value range of ΔE in the 2M2 shade was 0.41–3.81 and in the 3M2 was 0.57–3.86. Likewise, there was no significant difference in ΔE values of two groups ($P > 0.05$) [Table 2].

Table 1: The comparison of color parameters among the studied groups

Color	Color models (CIELab)	Porcelain type		P
		VMK (n=14)	VM13 (n=14)	
2M2 (n=14)	L*	73.34±0.59	72.07±0.44	>0.001
	a*	3.43±0.16	3.47±0.19	>0.001
	b*	16.77±0.85	17.09±0.31	>0.001
3M2 (n=14)	L*	70.92±0.57	69.65±0.25	>0.001
	a*	4.51±0.21	5.05±0.21	>0.001
	b*	18.56±0.91	19.14±0.35	>0.001

Table 2: Comparison of changes in color coordinates of VMK and VM13 in two shade

Group	ΔL	Δa	Δb	ΔE
2M2	1.37±0.80	-0.04±0.27	-0.32±0.84	1.63±0.84
3M2	1.27±0.78	-0.54±0.34	-0.58±0.96	1.71±0.96
P	0.775	0.000	0.451	0.807

Furthermore, in this study, the color of the samples was examined by direct observation. According to the results of the study, it was expected that the color difference of the samples could not be detected; the findings from visual observation confirmed this hypothesis (The kappa statistical test was used for this purpose and $P > 0.05$).

DISCUSSION

Our null hypothesis was that there was no color difference between VMK Master porcelain and VM13 porcelain. Our findings confirmed this hypothesis. Color measurement of human teeth and restorative materials has become an integral component of both clinical practice and dental research. Metal-ceramic restorations have been prized for their high strength, predictability, and excellent esthetic potential.^[22] One of the disadvantages of these restorations is the increase of light reflection because opaque porcelain covers the surface of the metal.^[23] One of the major problems of the metal-ceramic restorations is the difference between their color and natural tooth.^[23] Various studies have been reported the color discrepancies of these restorations. The processing variables such as the type of alloy and ceramic, temperature, particle size, applied pressure, particle packing, composition, and sintering atmosphere influence the color discrepancies.^[24,25] Base-metals alloys have generally been shown to be superior to other metal alloys.^[24,25] The most often used nonprecious dental alloy is Ni-Cr alloy and is used as an infrastructure in metal-ceramic restorations.^[24,25] Therefore, the present study used Ni-Cr alloy. The

VITA VMK Master and VM13 are the widely reliable porcelains used in metal-ceramic restorations. In clinical practice, 2M2 and 3M2 are two commonly advocated shades for VITA porcelain.^[17,26] Hence, in the present study, these two porcelains were used as well. In the present study, to reduce the problem of metamerism, a phenomenon in which the color of two objects look identical in one light source but look different under other light conditions^[23] (e.g. in sunlight vs. fluorescent light), the color matching of the metal-ceramic discs provided with the VITA shade guide was first reviewed and approved by five practitioners, and spectrophotometric shade analysis was applied. In the present study, significant differences were shown in the value of L* a* b* color space. Therefore, the porcelain shade type influenced the final restoration color. The results of this study confirm the results of previous studies, in other words, the type of porcelain system has a significant effect on the final color of metal-ceramic restorations.^[27-30] Seghi *et al.*^[27] in a spectrophotometric analysis of four porcelains systems with different shades showed that the final resultant color of metal-ceramic restorations depends on the type of porcelain. The difference between the L*, a*, and b* values contribute to a color difference in the porcelain build up. Anitha *et al.*^[31] in a study reported that there was a significant difference between the shade of VMK9 and d-SIGN porcelains in the nickel-chromium system. Therefore, the final color of the metal-ceramic specimens was significantly affected by both type of the alloy and the porcelain systems used.^[32] In the present study, the VMK-2M2 and VM13-3M2 porcelains had the lowest and highest a* value, respectively. Although all the digits were in the positive range of the a* axis, namely red, on this axis, the VM13-3M2 was noticeably darker than the other groups. In the b*-axis, the porcelains of the VMK-2M2 and VM13-3M2 groups had the lowest and the highest mean, respectively, and all samples showed a yellowish shade (positive b* values). In this study, in the b* axis the VITA porcelains were closer to yellow shade. The result of the present study is consistent with the results of Kourtis *et al.*^[8] study. In the present study, the mean L-axis of VMK-2M2 discs was higher than other porcelains; in other words, these specimens have a higher luminosity than other porcelains. In addition, among the three-color characteristics, the L* parameter has the highest difference between two porcelains compared to the two parameters b* and a* . Therefore, about 81% of 2M2 shade difference and 55% of 3M2 shade difference was related to the L* parameter. These results support the

Seghi *et al.*^[33] and Kourtis *et al.* studies.^[8,33] Douglas and Przybylska^[34] study in 1999 showed that the differences between two shades of L*, b*, and a* axes were 70%, 29%, and 1%, respectively.^[34] Value is the relative lightness or darkness of a color.^[35] Therefore, because the human eye is extremely sensitive to value, and according to the results obtained value is the most important factor in shade matching.^[36] Shade selection often requires comparing the differences in all three color axes L, a, b with each other, and the color spaces such as CIELab system were designed to approximate human perception of color. CIELab color space is a reference standard and is most commonly used for measuring object color. Color data collected in the dimensions of the CIELab color space can be archived and used for quantitative analysis (ΔE) of color.^[33] In this study, the mean ΔE between two porcelains in 2M2 and 3M2 shades was 1.63 and 1.71, respectively. This means that the color difference between the two porcelains is not noticeable and clinically considered to be acceptable. Similarly, there was no significant difference in the ΔE value of VMK and VM13 porcelains in 2M2 and 3M2 shades. The size and shape of porcelain powder affect the diffusion coefficient. The smallest color difference in porcelain VITA systems is due to the diffusion and light transmittance coefficient, which is approximately the same in two porcelains.^[24,37] Although two-layer porcelain is more similar to clinical conditions, in the present study, uni-layer porcelain was used. As it was shown in the previous studies, the two-layer porcelain makes a difference in color compared to uni-layer porcelain.^[26,38] Kourtis *et al.*^[8] in a study showed that the porcelain type (Vita omega and Ceramco silver) influences the color of the final restorations (in this study, A3 shade was used for all samples).^[20] The results of Corciolani *et al.*^[19] study in 2011 showed that the spectrophotometric evaluation of two types of porcelain, vita Omega 900 and VM13, conformed to three shade types, 2M3, 3M2, and 4M2, and was within acceptable clinical limits ($\Delta E \leq 3.3$).^[19] The VM13 also showed more similarity with the shade guide. In addition, the type of ceramic system, shade type, and layer thickness all affect the ΔE value.^[17] These results are consistent with the overall results of the present study. However, in the present study, the shade selection option (2M2 and 3M2) did not have a significant effect on the ΔE of studied samples. The reason for this difference is probably due to the type of porcelain, the type of metal infrastructure, and other factors affecting the final color of the restoration. Sarac *et al.*^[3] In a study designed for spectrophotometric

evaluation of the difference between the VITA classic shade guide and four different porcelain systems (Duceram Kiss, VITA Omega, Wieland Reflex, and Ivoclar IPS d. SIGN) for metal-ceramic restorations with different shades (A2, A3, and A3.5) showed no significant difference in the shade of four different veneering porcelain systems.^[3] Colorimetric method was initially described by various studies; however, this measurement can be erroneous due to the difference in absorption and diffusion, transmission, reflection, light of the samples, and even the displacement of the light ray to another path. This measurement error can be occurred as a result of the translucent optical properties of teeth and dental ceramics. By and large, increasing the translucency of a crown lowers its value because less light returns to the eye. The translucency of enamel fluctuates with the angle of incidence, surface texture, and luster, wavelength and level of dehydration. With increased translucency, light is able to pass the surface and is scattered within the restoration and can cause both false-positive and false-negative shade selection.^[17,32,33] The visual measurement is not only a result of the light entering into our eyes but also includes biological functions. It is the perception that decides and identifies what has been sensed. This can be understood through the experience of colors, the psychology of colors, and the meaning of colors, so the result of the visual measurement system can be accurate but not precise.^[22,3] Stevenson *et al.*^[18] in a study showed that the ΔE of visual shade determination in all cases was less than the spectrophotometric method.^[18] Spectrophotometers are fairly straightforward instruments with very few moving parts; they are therefore relatively easy to use and maintain and offer better accuracy.^[8] Spectrophotometers measure the amount of reflected or transmitted light at each wavelength and convert them to numerical values. Spectrophotometers are the valid intraoral optical electronic determination of a target color and verification of porcelain color during the fabrication of the restoration.^[27,39] On the other hand, the comparison between porcelains with this method can lead to significant error because the refractive index and the diffusion of light are different in various porcelains; hence, there is the issue of the accuracy of the radiometers being used today and are recommended for comparison of porcelains.^[17]

The purpose of this study was to evaluate two different color porcelains, VMK and VM13, and provided the accurate reconstruction of the shape

and color of porcelain. The results of present study due to spectrometric method have great potential for color measurements in terms of accuracy. It should be noted that the present study was *in vitro* study that differs from the natural environment of oral cavity. Therefore, the results may differ from the restoration of natural teeth. In addition, due to the lack of a similar study, it was not possible to compare the results of this study with other studies. In addition to the type of porcelain, the conditions for the preparation of metal-ceramic discs, metal structures, the proportion of the ingredients, the thickness of the samples, the firing conditions, as well as the color evaluation method can be effective in the final color of the restoration.^[40] Similar studies are required to examine the color differences of the porcelain and to select the most suitable porcelain.

CONCLUSION

According to this study, restorations conducted from different kinds of porcelain showed a significant difference in the amount of alterations in a^* , b^* , and L^* color parameters. However, the ΔE values were within clinically acceptable limits. VMK porcelain had high luminosity (L^*) than VM13. The highest values of a^* and b^* parameters were observed in VM13 porcelain. In addition, the shade difference between the two porcelains in 2M2 was $< 3M2$.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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