



# Influence of ceramic color and translucency on shade match of CAD/CAM porcelain veneers

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## Abstract

**Objective:** To investigate the influence of translucency of CAD/CAM ceramic milling blocks on the final color of porcelain veneer cemented using resin cement with two different opacities.

**Materials and methods:** A standardized incisal lap preparation was made on a maxillary right central incisor that was duplicated using composite resin material (Z250, A4, 3M ESPE). The resin dies were individually laser scanned (Bluecam, Sirona) in order to build a 3D model of the porcelain veneer on the CAD software (Cerec 3D). Three types of milling blocks were used to fabricate the required restorations: multichromatic, high translucency, and low translucency milling blocks (IPS Empress CAD, A1 Vita shade tab). The milled veneers were polished, glazed, and bonded on the resin dies using high opacity and low opacity resin cements (Panavia F2.0). A digital shade guide device (Easyshade Advance, Vita) was used to measure color parameters (CIE Lab values) at the incisal, middle, and cervical third of each cemented restoration.  $\Delta E$  values of the cemented veneers were calculated against the target color (A1).

**Results:** Cementation of porcelain veneers resulted in significant color change of the resin die (A4) as  $\Delta E$  values ranged between 8.9 and 13.7. However, the type of milling block did not have an observable effect on final color as the measured  $\Delta E$  values, against original die color, were very close for the multichromatic block ( $\Delta E = 10.7 \pm 0.1$ ), high translucency ( $\Delta E = 9.7 \pm 0.09$ ), and low translucency blocks ( $\Delta E = 13.4 \pm 0.11$ ). The opacity of the used resin cement did not affect the final shade match, as the observed  $\Delta E$  values using either high opacity and low opacity resin cement were less than 2 for the three used ceramic blocks. The greatest color difference was observed between the incisal third of multichromatic veneers ( $\Delta E = 8.9$ ) and the cervical third of low translucency veneers ( $\Delta E = 13.7$ ), while for the rest of the test groups this shift was not clinically observable ( $\Delta E < 2.5$ ).

**Conclusion:** Within the limitations of this study, the shade match of CAD/CAM porcelain veneers was not influenced by the translucency of used milling block or the opacity of the resin cement.

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## Introduction

Porcelain veneers have become an important treatment option for patients requiring superior esthetics of their anterior teeth with minimal tooth reduction.<sup>1</sup> A significant change in color and shape could be achieved using these minimally invasive restorations.<sup>2,3</sup> However, prediction of the final color of these restorations is a difficult job as it is influenced by several interacting variables as the color of tooth structure, type of resin cement, and color and translucency of the used milling block.<sup>4</sup> In a previous study, it was observed that the final color of porcelain veneers was directly influenced by the color of the underlying tooth structure, meanwhile the color of the resin cement had a negligible effect.<sup>5</sup>

The introduction of CAD/CAM technology to the dental field opened the door towards the fabrication of precise and accurate restorations using different materials. Nowadays, fabrication of precise and accurate restorations requires nothing more than a few keyboard clicks.<sup>6,7</sup> Recently esthetic ceramic blocks were introduced for chairside or in-lab CAD/CAM devices. Patients can receive their final restorations in the same visit, saving time and effort consumed in impression making and in the fabrication of the provisional restoration.<sup>8,9</sup> Nevertheless, the shade match dilemma remains a direct responsibility of the dentist, as an observable color mismatch is considered as a failure, especially in the anterior region of the mouth.<sup>10,11</sup>

Today, there is a wide variety of CAD/CAM ceramic blocks available for milling porcelain veneers that come in dif-

ferent sizes, colors, and translucencies.<sup>8</sup>

However, using a monochromatic milling block will eventually produce monochromatic veneers, which will require external staining in order to introduce individual effects. To solve this problem, a new multichromatic milling block was introduced to the market to allow the production of porcelain veneers with natural transitions of color between the more chromatic cervical region and the more translucent incisal edge. Additionally, new blocks with different translucencies became available in a step towards optimizing shade match of CAD/CAM produced porcelain veneers.

The aim of this study was to investigate the influence of color and translucency of CAD/CAM milling blocks on the final shade match of porcelain veneers cemented using two opacities of resin cement. The proposed null hypothesis was that the translucency of CAD/CAM milling blocks will not affect the final shade of the restoration.

## Materials and methods

### Preparation of the specimens

A maxillary right central incisor received an incisal lap preparation for porcelain veneers. The preparation accounted for a uniform 1 mm incisal reduction, 0.8 mm deep axial reduction ending at the cervical line and at the proximal contacts, and a 1 mm palatal reduction ending 1 mm below the incisal edge. After finishing the procedure, the prepared tooth was duplicated using composite resin restorative material (Z250, A4, 3M ESPE, Seefeld). The resin dies were



scanned using a high precision laser scanner (Bluecam, Cerec AC, Sirona) and the finish line of the preparation was manually traced using the CAD software (Cerec 3D, version 4.0).

Three types of leucite glass ceramic CAD/CAM milling blocks were selected for the fabrication of the final veneers, with the intention to shift the dark color of the resin dies (A4) to a lighter target color (A1). These blocks offered excellent esthetics in terms of color and translucency, accurate margins, light scattering effect and balanced chameleon effect: multichromatic, high translucency (HT), and low translucency (LT) milling blocks (IPS Empress CAD, A1, Ivoclar Vivadent). The produced veneers were finished, polished, and self-glazed according to the manufacturer's instructions. Add-on glaze was not used to prevent high reflection luster that could affect digital shade measurement. Twenty veneers were produced from every milling block.

### Cementation of the veneers

Each individual veneer was trial seated on its corresponding resin die for necessary fit correction. Half of the specimens of each group were cemented using a high opacity resin cement used for masking discolored teeth, while the other half was cemented using a low opacity resin cement, following the recommendations of the manufacturer (Panavia F2.0, Osaka).

### Digital shade determination

The cemented veneers with the corresponding resin dies were seated in

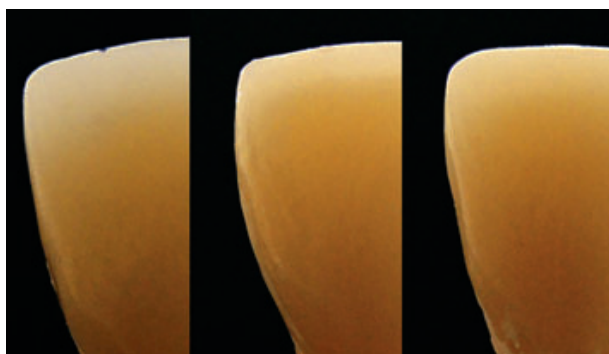
a students' teaching model (Frasaco Dental) that was mounted in a dummy head and neck. A dark background was placed inside the mouth and the digital shade guide device (Easyshade Advanced, VITA Zahnfabrik) was used to measure the color parameters at the cervical, middle, and incisal region of each veneer. The process was repeated three times for each veneer and the mean value was used, which eliminated errors during every individual reading. The device was calibrated before each use.

### Statistics

The color of the resin dies (A4) was measured and was used as a baseline measurement. CIE Lab color parameters of each specimen were compared to the baseline color of the resin die and  $\Delta E > 3.7$  was considered as a clinically observable color mismatch.<sup>5</sup> Standard statistical methods as one way and two way analysis of variance (ANOVA) were not used in this study because the selected significance level ( $\alpha = 0.05$ ) does not necessarily depict clinical relevance (a group with a significant difference in a color parameter ( $P < 0.05$ ) could have  $\Delta E$ , which is much smaller than 3.7).<sup>5</sup>

### Results

Cementing the veneers on the resin dies resulted in an observable color shift from a dark (A4) towards a lighter shade (A1). However, the type of milling block did not have an observable effect on final color as the measured  $\Delta E$  values, against baseline die color, were very



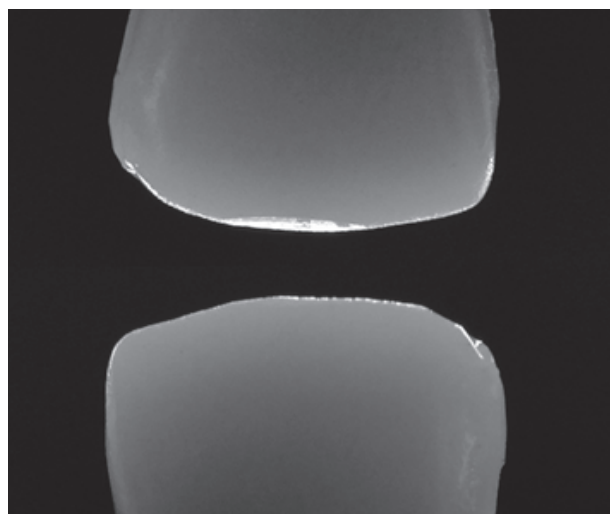
**Fig 1** Digital photograph demonstrating incisal edge of porcelain veneers milled from multichromatic (left), high translucency (middle), and low translucency (right) milling blocks.

close for the multichromatic ( $\Delta E = 10.7 \pm 0.1$ ), high translucency ( $\Delta E = 9.67 \pm 0.09$ ), and low translucency blocks ( $\Delta E = 13.36 \pm 0.11$ ) (Fig 1).

Comparisons between the cervical, middle, and incisal edge revealed that

the greatest color difference was observed between the incisal third of multichromatic veneers ( $\Delta E = 8.9$ ) and the cervical third of low translucency veneers ( $\Delta E = 13.7$ ), while for the rest of the test groups, this shift was not clinically observable ( $\Delta E < 2.5$ ). The greatest difference in L value was observed at the incisal edges of high opacity ( $L = 79 \pm 0.5$ ) and low opacity ( $L = 72 \pm 0.4$ ) ceramic veneers. Moreover, the position of the veneers inside the multichromatic milling block did not influence color measurement ( $\Delta E = 2.3$ ) (Fig 3).

The opacity of the used resin cement did not have a significant effect on the final shade match as the observed  $\Delta E$  values between the high and low opacity resin cements were less than 2 for the three used ceramic blocks, thus these data were excluded from the results. Previous data are summarized in Table 1.



**Fig 2** Grey digital image demonstrating difference in L value and translucency of two veneers made at two different positions of multichromatic block, more translucent position (upper) and less translucent position (low).



**Fig 3** Digital photograph of two veneers made at two positions of a multichromatic block, more translucent position (upper) and less translucent position (low).

**Table 1** Delta E value (SD) and L value of different ceramic blocks at different measurement locations

| Test group        | Measurement location | $\Delta E$ value | SD   | L value |
|-------------------|----------------------|------------------|------|---------|
| Multichromatic    | Cervical             | 10.65            | 0.21 | 76.56   |
|                   | Middle               | 10.74            | 0.22 | 75.93   |
|                   | Incisal              | 8.92             | 0.11 | 74.83   |
| High translucency | Cervical             | 9.58             | 0.12 | 73      |
|                   | Middle               | 9.67             | 0.12 | 73      |
|                   | Incisal              | 9.5              | 0.13 | 72.8    |
| Low translucency  | Cervical             | 13.71            | 0.14 | 79.5    |
|                   | Middle               | 13.36            | 0.1  | 79.1    |
|                   | Incisal              | 13.32            | 0.13 | 79      |

## Discussion

The results of this study led to the acceptance of the proposed null hypothesis, as neither the translucency of the ceramic block nor the opacity of resin cement improved the color match. The final color of porcelain veneers is the product of the interaction of color of the original tooth, and the translucency and thickness of both the resin cement and the ceramic veneer.<sup>12,13,14</sup>

In this study, three new CAD/CAM milling blocks were used to fabricate standardized porcelain veneers intended to shift the dark tooth color (A4) to a lighter target color (A1). The selected blocks are composed of leucite glass ceramic material – well known for its excellent esthetics and natural optical properties. Meanwhile, the manufacturer has controlled the translucency and chroma of these blocks in order to improve the final shade match of the milled restorations. The results of this study indicated that the three used blocks produced similar

results, even when used with two different opacities of resin cements (Fig 1). Different results could be expected using lithium disilicate CAD/CAM milling blocks (e.max CAD) that offer higher mechanical properties and more opacity compared to feldspathic blocks.

On the contrary, Davis and his associates observed marked color changes when different percentages of translucent porcelain were mixed with the porcelain slurry at 25% and 50% ratios used to manually build porcelain veneers.<sup>15</sup> Nevertheless, the produced color of the cemented veneers was neither the original tooth color nor the color of the selected porcelain slurry. In another study by the same authors, varying the percentage of translucent porcelain had little effect on the masking potential of the examined porcelain veneers.<sup>16</sup>

Controlling color in thin sections appears to be a difficult task, as the thin ceramic veneers must on one hand mask the color of the underlying tooth structure, and on the other hand must



not be too opaque in order not to compromise esthetics. Even a much more opaque material as alumina core failed to completely mask discolored tooth structure.<sup>17</sup> Similarly, variations in translucency of CAD/CAM milling blocks did not result in observable effect regarding color match, as all produced veneers failed to completely mask the baseline color (A4). For crown restorations, variations in translucency could be considered as a desirable option deserving further investigations.

On a parallel track, the opacity of resin cement was not effective in blocking the color of underlying tooth structure, as the final shade was almost comparable using high and low opacity resin cements. The limited cement film thickness prevented creation of an effective layer capable of blocking the color of underlying tooth structure.<sup>18</sup> Similar results were observed in a previous study using much thicker cement film layers (300  $\mu\text{m}$ ), which also failed to produce any observable effect.<sup>19</sup>

An interesting observation was that the L value of individual veneers measured against a dark background increased substantially after placement of the veneers on their resin dies. Such observation could be related in part to the translucency of these materials allowing limited transmission of the color of the dark background and to the presence of resin dies, which prevented light scattering on the internal surface of the veneers. A dental ceramist must thus measure color of porcelain veneers on tooth colored dies, otherwise a false darker color could be observed.

The resin dies used in this study had a homogenous single color (A4), which

is considered as a standardized background for every laminate veneer. For discolored teeth or those with an observable multichromatic appearance, with a marked shift in color between incisal and cervical thirds, multichromatic blocks could be an interesting treatment option. Further studies should be conducted to elaborate on the influence of location of the veneers inside these milling blocks on the final color (Fig 3). An interesting point to be mentioned is that judging color using numerical statistical tests as analysis of variance (ANOVA) could lead to inaccurate interpretation of the data. For example, a statistically significant color change ( $P < 0.05$ ) could fall far beyond the color recognition potential of the human eye. Relying on  $\Delta E$  values to judge color may solve this problem as it offers a digital value that can easily be compared to a set threshold level.<sup>4</sup>

Achieving acceptable esthetics using porcelain veneers cemented on discolored teeth or restored with a dark core build up material requires careful consideration regarding material selection in order to properly mask underlying color.<sup>7,8,13</sup> Based on the type of discoloration, the problem could be solved using complementary colors that could improve the color match of porcelain veneers.<sup>20</sup> Highly filled milling blocks with reduced translucency could improve the masking potential of porcelain veneers and enhance shade matching.

## Conclusion

With consideration to the materials used in this study, the shade match of CAD/



CAM produced porcelain veneers was not influenced by the translucency of the used milling block or the opacity of the resin cement.

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