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# Optical properties of current ceramics systems for laminate veneers

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ARTICLE INFO

*Article history:*
Received 28 May 2012
Received in revised form
8 November 2012
Accepted 12 November 2012

*Keywords:*
Laminate veneer
Optical property
Shade guide
Translucency
Chroma
Ageing

ABSTRACT

*Objectives:* Full-ceramic systems can be produced by different techniques (layering, heat-pressing, CAD/CAM) and have various compositions with different crystalline contents that may affect the optical properties of laminate restorations.
*Methods:* A total of 60 specimens were prepared from e.max Press, e.max CAD, Empress Esthetic, e.max Ceram, Inline, and ZirPress systems (A1 shade; diameter 10 mm; thickness $0.5 \pm 0.05$ mm). The $L^*$, $a^*$, and $b^*$ values, chroma and translucency (TP) of each system were recorded before and after ageing. The statistical analyses were performed by ANOVA, Tukey's tests and the paired sample *t*-test ($p < 0.05$).
*Results:* The $L^*$ value of the shade guide was significantly different from those of the full-ceramic systems; however, there were no significant differences between the $a^*$ values of Ceram, Esthetic, Inline and Zirpress. There were significant differences between the $b^*$ values of the shade guide compared with the full-ceramics except for e.max Press. The $L^*$ values decreased, and the $a^*$ and $b^*$ values increased after the ageing process for all groups. There were no significant differences between the $\Delta E$ values of the ceramic systems ($p > 0.05$). The TP values decreased, and the chroma value increased significantly after the ageing process ($p > 0.05$). The chroma of the shade guide was found to be the highest.
*Conclusions:* None of the full-ceramic systems was able to match the color of the shade guide. The chemical structures of the ceramic systems were more effective for determining the optical parameters than the fabrication techniques. Ageing caused full-ceramics to become more opaque, darker, reddish and yellowish.

## 1. Introduction

Due to the complex optical characteristics of tooth color, achieving successful aesthetics with a restoration is a difficult process for dental clinicians. Successful aesthetic restorations require knowledge of some basic principles and of the optical characteristics of restorative materials.[1,2] The problem of matching the color of natural teeth has been investigated and described. Dozic et al.[3] reported that small changes in the thickness and shade of the opaque and translucent porcelain layers can influence the definitive shade of all ceramic restorations. The challenge for laminate restorations is to achieve ideal color and aesthetics with limited preparation of the enamel.[4] Several factors have been reported to influence the definitive color of porcelain restorations, such as firing,[5] glazing[6] or the powder/liquid ratio.[7] Surface texture could also influence the optical properties of the ceramics, and it has

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http://dx.doi.org/10.1016/j.jdent.2012.11.013

been reported that the surface waviness had high correlation coefficients with optical parameters.[8]

Ceramics can be produced by different techniques, such as the traditional layering technique (veneered by condensing and sintering veneering porcelain), the fully anatomical technique (veneered by heat-pressing fluorapatite glass–ceramic ingots or CADCAM) or the cut-back technique (veneered by partial heat-pressing and subsequent layering).[9] Different heat temperatures, pressing pressure or the sintering techniques can also influence the porcelain texture. The different interface textures between the porcelain layers can change the direction of incident light and further change the optical properties of the ceramic restoration. Whether different techniques have the same influence on the appearance of full-ceramic restorations has not been determined.

Translucency is identified as one of the primary factors in controlling aesthetics and a critical consideration in the selection of materials.[10,11] The optical properties of teeth and porcelains include color and translucency in addition to hue, value and chroma.[10] All ceramic systems have various compositions with different crystalline contents, such as lithium disilicate, fluorapatite or leucite, which may affect the optical properties of these systems. An increase in the crystalline content to achieve greater strength generally results in greater opacity.[12]

To achieve a natural-looking restoration, two different steps need to be performed: select the best possible shade using a shade guide and/or an electronic shade-taking instrument, and reproduce this shade with an appropriate dental material.[1] Shade selection is usually made by comparing the natural dental tissues with a shade guide. Although this color selection procedure has been the subject of several investigations, it is still considered to be the best and is therefore one of the weakest links in aesthetic restorative dentistry.[2,13–17] Fazi et al.[18] showed that no consistent recommendations are provided by the dental manufacturers.Studies have compared the clinical performance of ceramics; however, the color compatibility of ceramic systems when constructing laminate veneers using different techniques and chemical structures is unknown. Establishing the correct match with the desired shade of the shade guide is still difficult. The durability of the color of the restorations may change after clinical use. In addition, only a few studies have focused on the optical properties of ceramics after ageing procedures, which is important for the long-term success of a restoration.[19–21]

The aim of this study was to determine the ability of ceramic systems to shade match with the shade guide and the optical properties of these systems after the ageing procedure. The null hypotheses were the following: (1) shade matching of all ceramic systems would be compatible with the shade guide and (2) optical differences would not be found between the ceramic systems after the ageing procedure.

## 2. Materials and methods

### 2.1. *Specimen preparation*

A total of 60 disc-shaped specimens of shade A1 were prepared from the IPS e.max Press, IPS e.max CAD, IPS Empress Esthetic, IPS e.max Ceram, IPS Inline, and IPS ZirPress ceramic systems (Table 1). The IPS e.max Press, IPS Empress Esthetic, and IPS ZirPress specimens were prepared by burning out a 0.5 mm thickness of wax with a diameter of 10 mm. The specimens were then heat-pressed (IPS Empress EP 600 press furnace) according to the manufacturer's directions. The IPS e.max Ceram and IPS Inline specimens were made by mixing ceramic powder with distilled water, which was then fired according to the manufacturer's directions. The IPS e.max CAD specimens were prepared from IPS e.max CAD ingots using a slow-speed diamond saw (ISOMET, Buehler Ltd., Lake Bluff, IL) under a constant flow of water, which served as a lubricant and coolant. All specimens were finished flat on a grinder/polisher with wet #400 to #1200 grit silicon carbide paper, and the thickness of the specimens was standardized (diameter, 10 mm; thickness, 0.5 ± 0.05 mm). Digital callipers (Electronic Digital Caliper, Shan, China) were used to measure the thicknesses, and the specimens were ultrasonically cleaned in distilled water for 10 min. The specimens were then coated on one side with a layer of neutral-shade glaze and fired at 765 °C. The specimens were then ultrasonically cleaned in distilled water for 10 min before the color measurements.

### 2.2. *Measurement of the optic parameters of the ceramics*

The color measurements were performed with a tristimulus colorimeter (ShadeEye NCC, Shofu, Kyoto, Japan) in a viewing booth under D65 standard illumination on a white background and were based on the ISO standards (ISO 7491). Before the experimental measurements, the colorimeter was calibrated according to the manufacturer's instructions, and the colorimeter was positioned in the middle of each sample. The $L^*a^*b^*$ color notation of each specimen was measured consecutively three times, and the average of the three readings was calculated to give the initial color of the specimen. The color values of all the ceramics were measured according to the Commission Internationale de l'Eclairage (CIE) $L^*a^*b^*$ system.$L$

**Table 1 – Ceramics used in the study.**

| Material | Manufacturer | Material type | Technique |
|---|---|---|---|
| IPS e.max Press | Ivoclar Vivadent, Schaan, Liechtenstein | Lithium disilicate | Pressing |
| IPS Empress Esthetic | | Leucite | Pressing |
| IPS ZirPress | | Fluorapatite | Pressing |
| IPS emax.Ceram | | Nano-fluorapatite | Layering |
| IPS Inline | | Leucite | Layering |
| IPS e.max CAD | | Lithium disilicate | Machining |