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# COLOR MATCH OF MODIFIED HIGH TRANSLUCENCY ZIRCONIA FRAMEWORKS

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## *ABSTRACT*

***Purpose:*** improve color match of full anatomical high translucency zirconia restorations using framework modifications.

***Materials and methods:*** Full anatomical high translucency zirconia frameworks (Cercon HT) received three modifications in framework design to allow room for layering conventional porcelain material: buccal window, extended buccal window, and occlusal clearance. Conventional porcelain was manually built according to manufacturer instructions. Color match of each framework design was compared to target color (A2, Vita classic shade guide) using a dental spectrophotometer (Vita Easy shade Advance). Delta E equation was used to measure color match of each framework design. Amount of transmitted light passing through each design was used to calculate translucency coefficient.

***Results:*** all framework modifications improved color match ($\Delta E<3.2$) compared to unmodified full anatomical design ($\Delta E=5.7$), however this improvement in color match was only limited to the area of framework modifications. Translucency of modified frameworks improved by addition of veneering porcelain (67%) compared to translucency of full anatomical framework (58%).

***Conclusion:*** Color match and translucency of full anatomical high translucency zirconia restorations improved using framework modifications.

**KEY WORDS**: High translucency, zirconia, framework, color match, spectrophotometer.

## INTRODUCTION

Thanks to accuracy and precision of modern computer assisted design and milling technology, design and fabrication of complicated zirconia frameworks requires nothing but few keyboard clicks. Due its superior mechanical and optical properties, zirconia became one of the most widely used all-ceramic framework materials offering high reliability and proven success rate.[1]

Zirconia is a white and opaque material, thus its clinical application was limited to fabrication of the supporting framework and as esthetic implant

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abutment [2,3]. To improve its color match, different coloring techniques were investigates as dipping in coloring solutions before sintering [4], or by the addition of coloring pigments to the original powder [5]. However, there was always a need for a layer of conventional glass ceramic veneer to improve the overall esthetic outcome.[6]

The translucency of zirconia could be improved by controlling the grain size of the materials restricting it to a fraction of a micrometer (0.2-0.3 $\mu$m) [7]. High translucency (HT) zirconia frameworks could be fabricated as full anatomical restoration without the need to add an esthetic veneer. A direct advantage would be reduction in fabrication time and cost, elimination of the chipping and delamination problem of the veneer ceramic, and management of cases with limited occlusal clearance [8]. The final color could be adjusted using superficial stains. However, HT zirconia restorations are not suitable in the region of high esthetic demands due to the limited possibility to control and adjust its final color.[9]

Today, the frameworks for CAD / CAM all-ceramic crown design have been based on empirical machine guidance rather than on clinical scientific data. Most of all CAD / CAM systems, crown frameworks are designed with arbitrary thicknesses of 0.4 to 0.6 mm [10]. It results in the non-uniform thickness of veneering porcelain. Zirconia frames should be constructed to provide the required thickness and support for porcelain veneering to minimize mechanical failure and to improve the esthetics of veneering porcelain.[11]

The aim of this study was to evaluate color match of HT zirconia restorations using different framework designs. The proposed hypothesis was that the color of HT zirconia restorations could be improved by addition of a layer of esthetic veneer in different regions of the restorations.

## MATERIALS AND METHODS

### Preparation of the specimens:

A student acrylic teaching model was used and a maxillary left first molar was fully prepared using manufacturer recommendations. The preparation insured 2mm occlusal clearance and at least 1.2 mm axial reduction. A 0.9 mm round chamfer finish line was placed 0.5 mm below the cervical line of the prepared tooth. The prepared tooth was laser scanned and a three dimensional image was transferred to CAD/CAM system (Cercon, Degedent, Hanau) to construct the necessary full anatomical framework design. Opposing dentition were used to construct occlusal relationship. Five framework designs were used to mill high translucency CAD/CAM milling blocks (n=10):

I. A conventional 0.5 mm thick framework with cervical shoulder on the lingual surface.

II. Full anatomical framework design

III. Full anatomical framework design with a buccal window to create room for layering conventional ceramic veneer.

IV. Full anatomical framework design with a buccal window extended to include half of the proximal surface on each side.

V. Full anatomical framework design with occlusal window to create room for layering conventional ceramic veneer.

Milled frameworks were fully sintered according to manufacturer recommendations . The target color of the fabricated restorations was chosen was A2 tab (Vita Classic shade guide). Conventional ceramic veneer was manually layered (Ceram Kiss, A2) in the opened window to restore morphology of the modified frameworks. Each added layer was individually fired beginning with framework modifier, dentine, enamel, and the finally added glaze. Add-on stain was used to improve color match of full anatomical framework design.

**Color measurements**

To isolate the influence of tooth color, the prepared crowns were filled with white clay were seated on a white background. Lab color parameters were recorded for the target shade tab (A2) as well for the fabricated restoration at standardized positions: mid buccal, mid occlusal, and mid lingual surfaces. Three measurements were recorded for each measuring point for each restoration using a dental spectrophotometer device (Vita easy shade advance, Vita). Accuracy of color match was calculated using ΔE equation which measures the absolute difference in Lab values between the target color (A2) and the fabricated restorations[12] :

$$\Delta E= [(L_{target}-L)^{\wedge 2}+(a_{target}-a)^{\wedge 2}+(b_{target}-b)^{\wedge 2}]^{\wedge 0.5}$$

ΔE values greater than 3.7 was considered as an observable color mismatch while values greater than 5.7 were considered as noticeable color mismatch requiring change of the restoration.[13]

**Evaluation of translucency parameter:**

A light box was used to control passage of a light beam collected from a D56 light bulb. The fabricated restorations were positioned to intersect the light passing through 3mm diaphragm while the tip of the dental colorimeter was placed on the opposing side to measure the light penetrating through the restoration. Difference between the intensity of the uninterrupted light beam ($L_{source}$) and between that passing through the restoration was used to calculate the translucency parameter at three different points: mid buccal, mid oclossal, and mid lingual surfaces.

$$\Delta L=[(L_{source}-L)^{\wedge 2}]^{\wedge 0.5}$$

**RESULTS**

Color analysis of the Lab values recoded for all tested framework designs indicated accurate color match for fully veneered and at the location of the opened windows of the modified framework designs (ΔE<2.1). Full anatomical framework and all locations composed of full wall thickness had a noticeable difference in color match (ΔE<4.8). There were no observable color difference in Lab color parameters between the ten specimens compositing every test group. Previous data are summarized in Table 1.

Regarding translucency parameter, addition of veneer ceramic material in the opened windows increased light transmission compared to full wall thickness composed of high translucency zirconia, as shown in Figure 1, and 2.

TABLE (1) Delta E values of the three readings at different measurement locations

| Lab values | Mid-buccal | | | Mid-lingual | | | Mid-occlusal | | |
|---|---|---|---|---|---|---|---|---|---|
| Full anatomical | 3.7 | 3.5 | 3.8 | 4.1 | 4.7 | 5.2 | 4.3 | 4.2 | 3.9 |
| Fully veneered | 1.3 | 1.4 | 1.6 | 1.5 | 1.2 | 1.4 | 1.2 | 1.4 | 1.6 |
| Buccal window | 1.6 | 1.5 | 1.7 | 3.8 | 3.8 | 3.9 | 3.1 | 2.9 | 3.2 |
| Extended window | 1.5 | 1.4 | 1.3 | 1.9 | 2.3 | 2.1 | 2.5 | 2.4 | 2.5 |
| Occlusal Window | 2.8 | 3.0 | 2.8 | 2.9 | 3.2 | 3.1 | 1.1 | 0.9 | 1.2 |

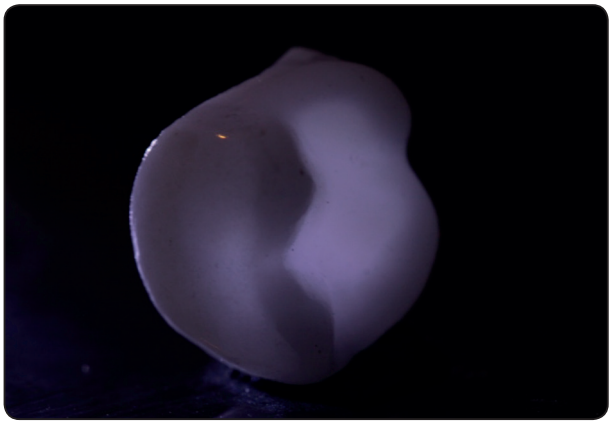

Fig. (1) Transmitted light passing through buccal window framework design

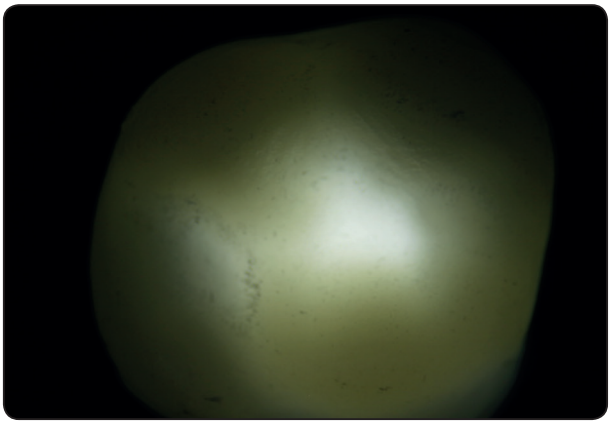

Fig. (2) Transmitted light passing through occlusal window framework design

## DISCUSSION

Relying on spectrophotometer to analyze color has many advantages the most important is handling color as a numerical variable which allow accurate comparison of different parameters without the interference of the effect of the surrounding light source or reflections.[14] The Lab color parameters of the chosen target color, A2 shade tab, were used as a reference to compare the color of different test groups. The add-on stains on the exterior surface of full anatomical zirconia frameworks improved color match considerably but to a certain limit as the final color remained detectable to human eye ($3.7<\Delta E<5.2$). These restorations could be used in the posterior region of the mouth with limited occlusal clearance and where the requirements of color match could be more forgiving. On the contrary, fully veneered high translucent zirconia restorations were able to achieve the highest color match compared to target color ($\Delta E<2.4$) which is ideal for the anterior region of the mouth and when there is sufficient room to build the veneer ceramic.[6]

Full anatomical zirconia frameworks reduce the time and cost spent to building the veneer ceramic and directly solve the problem of chipping and delamination of the esthetic veneer. They also could be used in cases with limited occlusal clearance and patients high masticatory functional loads. Unfortunately, they have limited esthetic outcome which relies on superficial stains. To solve this problem, the framework design was adjusted by opening a limited buccal, extended buccal, or occlusal windows to create room or addition of ceramic veneer which clinically improved color match compared to other regions of the restoration composed of full wall thickness made of high translucency zirconia. Selection of either design or modification of any of them could be adjusted to meet the demand of each clinical case thus combing the advantages of full anatomical and fully veneered zirconia frameworks in one restoration.

A previous study reported improvement in the esthetic outcome using similar approach.[15] Several parameters have a marked effect on the translucency of selected zirconia framework as type of ceramic veneer, coloring technique, and added stains. [16, 17]

On a parallel track, addition of ceramic veneer improved the amount of light passing through each restoration compared to full anatomical zirconia framework design. This feature could add more vitality to the restoration under transmitted light and could produce fluorescent effect at incisal edges and occlusal cusp tips, which was supported by Felberq RV et al, [18]. However the depth of the opened

windows could be adjusted to add only transparent or enamel porcelain to reduce the time and cost of adding opaque or dentine porcelain slurries.

## CONCLUSION:

The color and translucency of full anatomical zirconia frameworks could be improved by design modifications and by limited addition of ceramic veneer.

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