Effectiveness of optical illusions applied on a single composite resin veneer for the diastema closure of maxillary central incisors

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Abstract

Objective: To assess the esthetic effectiveness of four illusion techniques applied to a composite resin veneer for diastema closure between maxillary central incisors.

Materials and methods: An acrylic model with six natural maxillary anterior teeth was fabricated with a 2-mm diastema between the central incisors. Resin veneers were constructed on the left central incisor and the following cases were derived: V0: no veneer; V1: veneer without optical illusion features; V2: veneer with centralized interproximal ridges; V3: veneer with curved incisal edges; V4: veneer with gray pigment mesially/distally; V5: veneer with gray pigment on the developmental lobes. Digital printed photos of the models (13.2 x 17.8 cm, and 6.1 x 8 cm), with low, medium, and high smile lines and without a smile line (processed by Adobe Photoshop CS6) were shown to three groups of people (faculty members, senior undergraduate students, and patients; n = 25/group) for them to assess the overall size and width of the two central incisors. The results were analyzed by Pearson’s and chi-square goodness of fit tests.

Results: There was no significant influence in the estimation of the two central incisors as being the same size, according to the technique used (P = 0.869) and group of evaluators (P = 0.209). The estimated probability of assessing the tested incisor as wider was indicatively lower in V2 compared to V1 (adjusted odds ratio = 0.59; P = 0.088). The height of the smile line affected the evaluation of the veneers only in the large-sized photos.

Conclusions: No interference is the best esthetic decision concerning a 2-mm diastema closure when restoring only one central incisor with a laminate veneer. The next best option is to deliver a veneer with centralized interproximal ridges.

Introduction

The presence of a diastema between the maxillary central incisors is a common feature in adult dentition. A diastema distracts from the smile because the observer’s attention is usually drawn to it instead of to the overall dental composition.\(^1\)

Optimal closure of a diastema must always establish proper tooth proportions and symmetry.\(^2\)\(^-\)\(^4\) In an ideal treatment plan to correct a diastema between two maxillary central incisors, both incisors should be treated in order to close the diastema and end up with symmetrical teeth. In most clinical cases, and with the current bonding techniques, it is possible to treat both central incisors. Even in a case where the patient has an existing ceramic restoration on one central incisor, which is part of an extended implant-supported prosthesis that is in very good shape, it is still feasible to close the diastema with composite bonding restorations on both central incisors. Theoretically, though, the diastema could also be closed by treating only one central incisor, with the incorporation of an illusion technique in the bonding procedure. One could also explore the possibility of treating only one central incisor when closing an esthetically displeasing diastema.

As is well known, illusion refers to the condition where we create a visual perception of an object that differs from the real object. The incorporation of illusion techniques in dental esthetics for the purpose of making a tooth appear wider or smaller was presented by Goldstein in 1998.\(^5\) More recently, Fradeani proposed illusion techniques of dimensional variation through color change. In restorative dentistry, illusions incorporate changes to factors such as shape, lines, angles, curves, and shadows, as well as various combinations of these, to give a different visual perception.\(^7\)\(^,\)\(^8\) Shaping, contouring, staining, and/or changing the arrangement of teeth are usual ways of creating illusions\(^5\)\(^,\)\(^6\)\(^,\)\(^9\)\(^,\)\(^10\) as asymmetry becomes clearly identifiable and quantifiable.\(^11\)

The incorporation of illusions in dental restorations has been proposed but has never been challenged or questioned via rigorous scientific examination. In this article, a research design is presented that scientifically examines the merit of the illusion techniques mentioned earlier. Four optical illusions were selected for examination. The techniques were applied on a single composite resin veneer for diastema closure between maxillary central incisors. The evaluators were professionals and laypeople who evaluated printed digital photos taken of an in vitro model with natural teeth.

The two null hypotheses were: 1) that there is no effect in the estimation of the overall size and/or width of the central incisors dependent on the illusion technique used, level of dental expertise, and gender of the evaluator; and 2) that the size of printed photos from which the said evaluation is made, as well as the smile line positions, are not important. This type of research has not been performed before, and it is expected that the results could provide valuable information to dental clinicians.
Materials and methods

Approval for this investigation was received from the Ethics Committee of the Dental School, University of Athens, Greece. Thereafter, six natural maxillary anterior teeth, recently extracted from the same individual for periodontal reasons and stored in distilled water, were used for the fabrication of an acrylic model. Gum reproduction on the model was made with acrylic resin (45ºC for 50 min; ProBase Cold, Ivoclar Vivadent) and acrylic stains were used for esthetic individualization (Castdon Intense, Dreve). The maxillary left central incisor was removable for practical reasons during veneer fabrication. The storage of the model throughout the duration of the experiment was in a plastic container in a dark environment with 100% humidity.

The teeth were arranged so that the optical width of the lateral incisor was approximately 65% of that of the central incisor, and the width of the canine was almost 80% of that of the lateral incisor. The lateral incisors were 1.5 mm shorter than the central incisors, and a 2-mm diastema was formed between the central incisors. This initial condition was called V0 (Fig 1). Thereafter, preparation for a laminate veneer was performed on the removable left central incisor, with an incisal overlap of 2 mm without palatal chamfer. The preparation was designed in such a way that a consistent thickness of 0.5 mm for the resin veneer could be produced buccally. There was no interproximal reduction, and a cervical chamfer finish line was placed 0.5 mm away from the acrylic gum border. The preparation was within the enamel and without sharp line angles, for maximum conservation of tooth structure and strength of the resin veneers. The preparation began with a depth cutter diamond bur (850, 0.16 mm, 10 mm Comet GEBR, Brasseler) and proceeded with a cylindrical round-ended diamond rotary cutting instrument (856, 0.16 mm, 10 mm, Comet GEBR) at different angles following the convexity of the tooth, under constant water irrigation.

Then, five veneers were constructed over the left central incisor, with the same system of composite resins (Renamel, Cosmedent). The basic layering step corresponded to the initial placement of a 0.3-mm A2 Renamel nanohybrid layer (Vita Classical, Vita Zahnfabrik). Then, a 0.2-mm layer of A2 Microfill Renamel was placed to cover the aforementioned layer. All veneers were constructed under standardized photopolymerization procedures (led irradiation, 40 s/resin layer; B-Max, Techno-Gaz) and finished/polished with the same polishing system (Mini Flexi-Discs/Enamelize Polishing Paste/FlexiBuff Mini, Cosmedent) by
the same operator. The first two illusion techniques applied were exterior interventions and were produced by finishing (Fig 2a and b). The last two techniques were interior interventions (Fig 2c and d) and were produced by applying a gray tint (Renamel Creative Colors, Cosmedent) over the first nanohybrid layer and before the last microfill layer of the system. Each veneer was removed after fabrication, and the next one was constructed over the same preparation.

Fig 2  Schematic view of the illusions applied and tested in the present study: (a) centralizing interproximal ridges; (b) curving incisal edges; (c) applying gray pigment mesially/distally; (d) applying gray pigment on the developmental lobes. (Redesigned from Goldstein R. Esthetics in Dentistry, ed 2, vol 1. Principles, communications, treatment methods. London: Decker BC, 1998:133–181.)

Fig 3  Veneer without any optical illusions (V1).
Consequently, the veneers derived were: V1: without any optical illusion features; V2: with centralized interproximal ridges; V3: with curved incisal edges; V4: with gray pigment mesially/distally; V5: with gray pigment on the developmental lobes (Figs 3 to 7). Adobe Photoshop CS6 software was used to process the digital photos in order to apply lips on the model, producing images of high, medium, and low smile lines according to previously published information\textsuperscript{15-18} (Figs 8 to 11).

Digital photos of the restorations were then taken (Nikon D3200, AF-S Micro Nikkor 105 mm; R1C1 Speedlight flash system) under the same environmental lighting conditions (daylight-balanced CRI-corrected fluorescent tubes, 5,500ºK, CRI 95%), corrected through measurements from a one-half magenta filter determined by color meter (Konica Minolta Color Meter IIIF) over a triangular setup placement of the object in accordance with the two units of the Speedlight system. A standard model–camera
distance (30 cm) was applied, and the camera was used by the same operator. Additionally, photos were printed (Canon PIXMA-iP6600D) with multi-colored ink (Canon PIXMA Chromalife 100; colors 8C, 8M, 8Y, 8PM, 8BK, and 8PC) on glossy photo paper (Canon GP-501 A4, 21 x 29.7 cm, extra premium), in two sizes (large: 13.2 x 17.8 cm, and small: 6.1 x 8 cm).

The evaluators were faculty members, senior undergraduate students, and
patients of the Dental School, National and Kapodistrian University of Athens, Greece, having no vision problems. They all signed consent forms of availability during the test period. All possible participants undertook the Ishihara test for color blindness. Faculty members were selected from the Orthodontics, Prosthodontics, and Operative Dentistry departments. They were evenly distributed among all levels of the academic hierarchy. Senior postgraduate students

Fig 10  (a to f) All cases with a medium smile line.

Fig 11  (a to f) All cases with a high smile line.
in their last semester of studies were randomly selected. Patients were selected by a draw from those visiting the postgraduate clinic of the Operative Dentistry department for a period of 6 months. Therefore, from a list of 105 people who fulfilled the aforementioned criteria, 75 people were randomly selected to participate. Each group contained 25 subjects.

The observation conditions (distance, lighting conditions, etc.) were stable throughout the study period, as is suggested elsewhere. More specifically, the evaluation procedure took place within the period of 1 week, in the same room under the lighting conditions mentioned previously. The viewing conditions of the respondents were standardized so as to minimize light reflections from the glossy surface of the printed photos. Each photo was observed for 30 s at a fixed distance of 40 cm. At each appointment, photos were shown to the evaluators for estimation in a random order so as to avoid systematic bias. At the first appointment, small-sized photos of all six cases combined, with and without lip lines, were shown separately to each evaluator. At the second appointment, large-sized photos of the six cases, separately and combined, with and without lip lines, were shown for evaluation.

In a pilot phase, 20 subjects who were not participants of the present study filled in the questionnaire in order to investigate its clarity. The final questionnaire contained general information about the participants (for example gender, education level) and questions concerning the respondents’ rating of the width and the overall size of the veneered left central incisor. The questions were asked for small- and large-sized photos, with and without lip lines, in random order (Table 1).

**Statistical analysis**

The potential association between qualitative characteristics was assessed through Pearson’s chi-squared test. Evidence for a specific preference among images was based on the chi-squared goodness of fit test. The nonparametric Stuart-Maxwell test was applied to identify differences in image preferences among the different smile lines. In those cases, the Bonferroni adjustment was applied to correct for Type I error inflation due to multiple comparisons.

Multivariable analysis of the probability of considering equal size for the two central incisors or the left maxillary central incisor as wider was based on logistic regression for clustered data. The parameter estimation was performed through generalized estimating equations in order to take into account the inherent association between multiple responses of a given study participant. No a-priori assumptions were made about the within-subject correlation structure (ie, an unstructured correlation matrix was assumed). The final models included the technique, group, and gender as independent variables.
Table 1  Study questionnaire

**Small photos**

- **Estimation with the presence of lips (low smile line)**

  Question 1 [All photos were shown together: 0 + 1 + 2 + 3 + 4 + 5]
  
  In which photo do you think the two central incisors are the same width (in descending order of preference, i.e., mark the one with the closest dimensions first)?
  
  0 …… 1 …… 2 …… 3 …… 4 …… 5 ……

  In which photo do you think the two central incisors are the same size?
  
  0 …… 1 …… 2 …… 3 …… 4 …… 5 ……

  *Questions 2–4 [The same question was asked for medium and high smile lines, as well as for without lips]*

- **Estimation without lips**

  Question 5 [Each photo was shown alone: V0]
  
  Do you think the size of the two central incisors is the same?
  
  Yes …….. No ……..

  If your answer is ‘No’, which tooth do you think is wider?
  
  No. 11 …….. No. 21 …….. Neither ……..

  *Questions 6–10 [The same questions were repeated for V1, V2, V3, V4, and V5]*

**Large photos**

- **Estimation with the presence of lips (low smile line)**

  Question 11 [All photos were shown together: 0 + 1 + 2 + 3 + 4 + 5]
  
  In which photo do you think the two central incisors are the same width (in descending order of preference, i.e., mark the one with the closest dimensions first)?
  
  0 …… 1 …… 2 …… 3 …… 4 …… 5 ……

  In which photo do you think the two central incisors are the same size?
  
  0 …… 1 …… 2 …… 3 …… 4 …… 5 ……

  *Questions 12–14 [The same question was asked for medium and high smile lines, as well as for without lips]*

- **Estimation without lips**

  Question 15 [Each photo was shown alone: V0]
  
  Do you think the size of the two central incisors is the same?
  
  Yes …….. No ……..

  If your answer is ‘No’, which tooth do you think is wider?
  
  No. 11 …….. No. 21 …….. Neither ……..

  *Questions 16–20 [The same questions were repeated for V1, V2, V3, V4, and V5]*
Results

The descriptive characteristics of the study population are presented in Table 2. The gender distribution was similar across all groups of evaluators, with the proportion of women ranging from 44.0% to 54.7% ($P = 0.222$). The education level of the patient group differed significantly from that of faculty member group and senior undergraduate student group ($P < 0.001$).

The height of the smile line did not affect the evaluation of veneers in the small-sized photos, but had a significant influence in the larger-sized ones. More specifically, differences in the distribution of the sequence of preference of veneers for the low vs medium and medium vs high smile lines were statistically significant, irrespective of the criterion used (width equality, and overall size equality of the central incisors) (Table 3).

Overall, there were statistically significant differences concerning the sequence of preference of veneers (in all cases, $P \leq 0.010$), regardless of the size of the photos. Table 4 shows the results from a multivariable analysis of factors potentially influencing the probability of estimating the two central incisors as equally sized. None of the examined factors (technique, evaluator group, gender, or education level) had a statistically significant effect. All techniques were associated with increased probabilities of considering the two central incisors as equally sized when compared to V1 (veneer without optical illusion features). In other words, all adjusted odds ratios were > 1, but differences were not statistically significant (global test: $P = 0.869$).

### Table 2 Descriptive characteristics of the study population (N = 75)

<table>
<thead>
<tr>
<th></th>
<th>Faculty members</th>
<th>Senior undergraduate students</th>
<th>Patients</th>
<th>Total</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td>N (%)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.222</td>
</tr>
<tr>
<td>Men</td>
<td>14 (56.0)</td>
<td>12 (48.0)</td>
<td>8 (32.0)</td>
<td>34 (45.3)</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>11 (44.0)</td>
<td>13 (52.0)</td>
<td>17 (68.0)</td>
<td>41 (54.7)</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Primary</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (4.0)</td>
<td>1 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>8 (32.0)</td>
<td>8 (10.7)</td>
<td></td>
</tr>
<tr>
<td>Technical/College</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>7 (28.0)</td>
<td>7 (9.3)</td>
<td></td>
</tr>
<tr>
<td>University</td>
<td>25 (100.0)</td>
<td>25 (100.0)</td>
<td>9 (36.0)</td>
<td>59 (78.7)</td>
<td></td>
</tr>
</tbody>
</table>
### Table 3  Distribution of choice of veneers based on a) width equality, and b) overall size equality of central incisors according to height of smile line (results from large-sized photographs)

#### a) Same width of central incisors

<table>
<thead>
<tr>
<th>Smile line</th>
<th>Low (A)</th>
<th>Medium (B)</th>
<th>High (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technique</strong></td>
<td><strong>N (%)</strong></td>
<td><strong>Technique</strong></td>
<td><strong>N (%)</strong></td>
</tr>
<tr>
<td>V0</td>
<td>25 (33.3)</td>
<td>V0</td>
<td>43 (57.3)</td>
</tr>
<tr>
<td>V1</td>
<td>36 (48.0)</td>
<td>V1</td>
<td>6 (8.0)</td>
</tr>
<tr>
<td>V2</td>
<td>9 (12.0)</td>
<td>V2</td>
<td>16 (21.3)</td>
</tr>
<tr>
<td>V3</td>
<td>2 (2.7)</td>
<td>V3</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td>V4</td>
<td>1 (1.3)</td>
<td>V4</td>
<td>6 (8.0)</td>
</tr>
<tr>
<td>V5</td>
<td>2 (2.7)</td>
<td>V5</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>75 (100.0)</td>
<td><strong>Total</strong></td>
<td>75 (100.0)</td>
</tr>
</tbody>
</table>

A vs B: $P < 0.001$; B vs C: $P = 0.024$

#### b) Same size of central incisors

<table>
<thead>
<tr>
<th>Smile line</th>
<th>Low (A)</th>
<th>Medium (B)</th>
<th>High (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technique</strong></td>
<td><strong>N (%)</strong></td>
<td><strong>Technique</strong></td>
<td><strong>N (%)</strong></td>
</tr>
<tr>
<td>V0</td>
<td>20 (26.7)</td>
<td>V0</td>
<td>38 (50.7)</td>
</tr>
<tr>
<td>V1</td>
<td>42 (56.0)</td>
<td>V1</td>
<td>14 (18.7)</td>
</tr>
<tr>
<td>V2</td>
<td>12 (16.0)</td>
<td>V2</td>
<td>17 (22.7)</td>
</tr>
<tr>
<td>V3</td>
<td>0 (0.0)</td>
<td>V3</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td>V4</td>
<td>1 (1.3)</td>
<td>V4</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td>V5</td>
<td>0 (0.0)</td>
<td>V5</td>
<td>2 (2.7)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>75 (100.0)</td>
<td><strong>Total</strong></td>
<td>75 (100.0)</td>
</tr>
</tbody>
</table>

A vs B: $P < 0.001$; B vs C: $P = 0.045$
Table 4  Results from a multivariable logistic regression model for the probability of estimating the two central incisors as equally sized

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds ratio</th>
<th>95% C.I.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique</td>
<td></td>
<td></td>
<td>0.869</td>
</tr>
<tr>
<td>V1 *</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2</td>
<td>1.51</td>
<td>(0.63, 3.58)</td>
<td>0.353</td>
</tr>
<tr>
<td>V3</td>
<td>1.16</td>
<td>(0.42, 3.19)</td>
<td>0.770</td>
</tr>
<tr>
<td>V4</td>
<td>1.16</td>
<td>(0.42, 3.23)</td>
<td>0.772</td>
</tr>
<tr>
<td>V5</td>
<td>1.00</td>
<td>(0.35, 2.83)</td>
<td>1.000</td>
</tr>
<tr>
<td>Evaluator groups</td>
<td></td>
<td></td>
<td>0.209</td>
</tr>
<tr>
<td>Faculty members*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior undergraduate students</td>
<td>2.52</td>
<td>(0.71, 8.95)</td>
<td>0.154</td>
</tr>
<tr>
<td>Patients</td>
<td>3.05</td>
<td>(0.87, 10.68)</td>
<td>0.081</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.647</td>
</tr>
<tr>
<td>Male*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.24</td>
<td>(0.50, 3.09)</td>
<td>0.647</td>
</tr>
</tbody>
</table>

*Reference group

Faculty members had lower probabilities of considering the two central incisors as equally sized compared to senior undergraduate students and especially patients, but differences were still not statistically significant ($P = 0.209$). Finally, the differences between male and female were negligible, with the corresponding adjusted odds ratio being close to 1, and the corresponding $P$ value being much higher than the nominal statistical significance level ($P = 0.647$).

Table 5 shows the results of a similar analysis for the probability of estimating the left maxillary central incisor as wider. Differences due to technique were not significant ($P = 0.250$), but all techniques were associated with lower probabilities of considering the left maxillary central incisor as wider compared to V1 (ie, all odds ratios were $< 1$). The technique which resulted in the most-preferred veneer was V2, as it was associated with the lowest odds ratio compared to V1, and the corresponding $P$ value was approaching the nominal significance level ($P = 0.088$). Differences in evaluator groups were statistically significant, with faculty members being almost four times more likely to detect that the left maxillary central incisor was wider compared to the patient group ($P = 0.007$).
Table 5  Results from a multivariable logistic regression model for the probability of estimating the left central incisor as wider

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds ratio</th>
<th>95% C.I.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique</td>
<td></td>
<td></td>
<td>0.250</td>
</tr>
<tr>
<td>V1*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V2</td>
<td>0.59</td>
<td>(0.33, 1.08)</td>
<td>0.088</td>
</tr>
<tr>
<td>V3</td>
<td>0.70</td>
<td>(0.35, 1.39)</td>
<td>0.307</td>
</tr>
<tr>
<td>V4</td>
<td>0.70</td>
<td>(0.35, 1.39)</td>
<td>0.308</td>
</tr>
<tr>
<td>V5</td>
<td>1.00</td>
<td>(0.50, 2.01)</td>
<td>&gt; 0.999</td>
</tr>
<tr>
<td>Evaluator groups</td>
<td></td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>Faculty members*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior undergraduate students</td>
<td>0.83</td>
<td>(0.26, 2.62)</td>
<td>0.750</td>
</tr>
<tr>
<td>Patients</td>
<td>0.24</td>
<td>(0.08, 0.67)</td>
<td>0.007</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td>0.971</td>
</tr>
<tr>
<td>Male*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.02</td>
<td>(0.44, 2.37)</td>
<td>0.971</td>
</tr>
</tbody>
</table>

*Reference group

Senior undergraduate students detected the difference in width slightly less frequently than faculty members, but the corresponding difference was not statistically significant ($P = 0.750$). Finally, in terms of detecting the width difference, the differences between male and female were practically nonexistent (odds ratio 1.02; $P = 0.971$).

Discussion

Generally, a midline discrepancy of $< 2$ mm between the maxillary dental midline and the facial midline is considered to be acceptable.$^{23,24}$ Of course, an excessive interproximal space of $\geq 2$ mm can be rated as unattractive$^{25}$ in western countries, but attractive in African countries.$^{26}$ Furthermore, it is reported that orthodontists do not rate a diastema unattractive when it ranges from 1.0 to 1.5 mm, while for general dentists and laypeople the threshold is 2.0 mm.$^{27}$

Clinically, most cases with a diastema of $\geq 2$ mm present a dynamic therapeutic challenge.$^{1-3}$ Direct composite resin restorations and direct or indirect composite veneers are a conservative solution that can provide a good treatment
outcome in these cases. Both esthetics and function are enhanced, and usually little or no tooth preparation is required. Moreover, contemporary composite materials are aesthetic, durable, and affordable, and have a longevity of adhesion to enamel that is well documented.\(^1\),\(^2\)\(^8\) Physical and chemical improvements over the years have optimized color stability and improved wear resistance.\(^2\)\(^8\)

Therefore, for this study, a diastema was chosen for evaluation, with a single restoration involving only one central maxillary incisor and a diastema limited to 2 mm. Illusion techniques were applied during the construction of the composite veneers so that the restored tooth appeared somehow equal in size to the untreated one. Although the aforementioned techniques have been proposed in the literature,\(^5\),\(^6\) to the authors’ best knowledge there are no studies comparing the optical effects of their application. The clinical relevance of the present study was thus a major challenge.

Initially, the construction of the model had to follow certain proportions. The golden proportion has been proposed as the most harmonious tooth-to-tooth ratio.\(^29\)-\(^31\) However, Tay Chu Jon et al.\(^7\) reported that in only 17% of cases where patients were restored strictly within the golden proportion would the result be an excessively narrow maxillary arch and compression of the lateral segments. Therefore, for the present study, the teeth were arranged in an arch so that the optical width of the lateral incisor was approximately 65% that of the central incisor, and the width of the canine almost 80% that of the lateral incisor.\(^8\)

The second challenge was the evaluation of the printed digital photos. Of course, the estimation would have corresponded better to clinical conditions had the evaluators estimated the veneered tooth in actual clinical conditions. However, for practical and ethical reasons, estimation of the printed photos was the study method chosen, with all relevant precautions taken to minimize the effect of light reflection from the glossy printed photos. It is noted that perhaps the estimation of photos on a high-definition computer screen would be an excellent alternative method for future studies.

Additionally, the size of estimated photos is barely described in the literature. Therefore, for the present study, two sizes were chosen as the most-frequently printed dimensions, being 6.1 x 8 cm (small), and 13.2 x 17.8 cm (large). It was found that large-sized photos influenced the assessment of the width and overall size equality of the two central incisors, both in high smile line photos and those without lips. On the contrary, the height of the smile line seemed not to interfere significantly in the small-sized photos. This result is considered logical, since more details can be seen in large-sized photos, as is stated elsewhere.\(^32\)

Importantly, while evaluators are usually specialists (eg, orthodontists, prosthodontists, and cosmetic dentists), in this study they were general dentists of different ages and experience, undergraduate dental students, and patients (laypeople).\(^1\),\(^1\),\(^7\),\(^1\),\(^9\),\(^1\),\(^9\),\(^2\),\(^7\),\(^2\),\(^7\),\(^3\)-\(^3\)\(^6\) The perception of esthetic alterations by laypeople and professionals is discussed elsewhere.\(^1\),\(^3\),\(^2\),\(^7\),\(^3\)\(^6\) For example, it has been mentioned that any maxillary incisal cant (angular deviation of the midline from a vertical plane) is easily perceived by dental professionals and laypeople.\(^1\),\(^2\)\(^5\)
In addition, dentists and laypeople are able to detect features that are out of balance or unharmonious, or asymmetric alterations that render the teeth unattractive.\textsuperscript{25,27} It is important to mention that in the present study, although no statistically significant differences were reported concerning the selection of the best veneer by the various evaluator groups, the dental professionals were able to define the proper dimensions of the veneers more accurately than were the students, and even more so compared to the patients. This result corresponds to other findings where there is a diminished capability of distinction in the general population compared to dental professionals.\textsuperscript{11,15,25,32,35,39-41}

No influence whatsoever was found concerning the influence of gender on the perception of the most-preferred veneer, as regards its overall size or width. Elsewhere though, females have tended to give slightly higher ratings for most of the estimated smile discrepancies, which suggests that they may be characterized by a higher esthetic sensibility.\textsuperscript{25}

Therefore, the first null hypothesis of the study was accepted, since there was no effect in the estimation of the overall size and/or width of the central incisor depending on the technique, level of expertise of evaluators, and gender of evaluators. The second null hypothesis was rejected because the size of the printed photos and the position of the smile line did affect the estimation procedure of the most-preferred veneer.

Conclusions

Within the limitations of the present study, the following conclusions can be drawn:

- No interference is the best esthetic decision concerning the closure of a 2-mm diastema between two central incisors if the plan is to restore only one of them with a laminate veneer. The next best option is to deliver a veneer with centralized interproximal ridges.

- Technique, level of dental expertise of the evaluator, and gender of the evaluator do not affect veneer selection.

- Smile line affects veneer selection only in large-sized photos.

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Conflict of interest statement

The authors do not have any financial interest in the companies whose materials are mentioned in this article.
References


