

# Influence of the Vertical Position of Maxillary Central Incisors on the Perception of Smile Esthetics Among Orthodontists and Laypersons

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## ABSTRACT

**Objective:** The purpose of this study was to determine the perception of smile esthetics among orthodontists and laypeople with respect to different upper central incisor vertical positions in a frontal smile analysis.

**Materials and Methods:** A frontal close-up smile photo of an adult Caucasian woman was selected. The patient had healthy upper anterior dentition and had no history of orthodontic treatment. Images were altered in order to create six different central incisor vertical positions in 0.5-mm increments. All images were assessed in three different views: full smile, gingival close-up excluding incisal edges, and incisal close-up excluding gingival margins. Images were randomly assembled in an album, which was given to 120 judges: 60 orthodontists and 60 laypersons. Each rater was asked to evaluate the attractiveness of the images using the visual analog scale. The data collected were then statistically analyzed.

**Results:** The highest rated smiles showed two notable characteristics: the central-to-lateral incisal step was 1.5 mm; and the central incisor gingival margins matched the laterals, and both were 0.5 mm below the line of the canine gingival margins. The least attractive smile was the one with no step between the centrals and laterals, and with the central incisor gingival margins 1.0 mm above the canine gingival margins.

**Conclusion:** The results of this study indicate that slightly extruded upper central incisors are more esthetically preferred than intruded.

## CLINICAL SIGNIFICANCE

The upper central incisors are the key determinant in evaluating smile esthetics, and thus, the assessment of their ideal vertical positioning is an aspect of paramount importance.

(J Esthet Restor Dent 25:392–403, 2013)

## INTRODUCTION

In order to accomplish optimal dental esthetic results when treating patients of all ages, it is of paramount importance for the clinician to follow established esthetic guidelines. For many years, these parameters

were only based on authors' opinions rather than on evidence-based literature.<sup>1–9</sup> These guidelines were biased because the concept of beauty is tied to great subjectivity and is strongly influenced by the opinions of others.<sup>10–12</sup> For instance, literature suggests that dentists and laypeople show different perceptions of

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smile esthetics when evaluating a variety of orofacial characteristics and that dentists, especially orthodontists, are more sensitive in detecting deviations from ideal than the general public.<sup>13–18</sup>

In order to provide more objective guidelines regarding the perception of smile esthetics, numerous studies were performed using digital image manipulation.<sup>13–27</sup> Characteristics that were better elucidated utilizing this technology include: the smile arc;<sup>13,19–22</sup> optimal amount of gingival display;<sup>14,15,19,23</sup> ideal amount of buccal corridors;<sup>13,19,20</sup> prominence of dental and gingival asymmetries;<sup>14–16,19</sup> influence of a midline diastema;<sup>15,21,24</sup> impact of midline and long axis deviations;<sup>14,16,19</sup> and importance of upper incisor size, proportion, anatomy, and angulation.<sup>17,18,24–27</sup>

Although a great number of smile esthetics guidelines were published, some important parameters used as clinical references have not yet been scientifically validated. For instance, vertical position of the upper central incisors, taking into account both the gingival margins and the incisal edges, has been the focus of great attention recently. According to a frequently cited reference, the gingival margins of the central incisors should match the canines and should be slightly above the gingival margins of the lateral incisors.<sup>1–3,5–8</sup> Although orthodontists and professionals from other specialties have based their esthetic treatment plans on this recommendation, the question still remains whether this approach results in the most ideal esthetic result. In addition to this guideline, when altering maxillary central incisors vertical position, not only the gingival margin will be modified but also the incisal edges position and its relationship to the lateral and canines incisal edges.

The upper central incisors vertical position plays a vital role on the overall smile esthetics and its closely related to the definition of the smile arc. According to the literature in an ideal arrangement of that arc upper anterior incisal edges should coincide or follow the contour of the lower lip while smiling.<sup>7,8,28</sup> Therefore, if one strictly try to match upper centrals gingival margin with canines margins and not take into account the

centrals height and incisal edges position, it may result in a smile in which the upper central incisal edges are above those of the canines, yielding an unpleasant smile that has been referred to as flat, reverse, or nonconsonant.<sup>8,13,20,28</sup> In a clinical scenario, some situations may result in a reverse smile arc such as: (1) attempting to achieve canine guidance by extruding the upper canines; (2) because of attrition of the maxillary central incisors without restoration of the incisal edges; (c) improper bracket positioning during orthodontic treatments; (d) indiscriminate leveling of the maxillary arch during orthodontic treatments, thus flattening the smile arc; etc. Incisal positioning becomes even more important as we consider that youthful smiles show more upper incisors, whereas aged smiles tend to show less.<sup>29</sup> Therefore, more recent recommendations suggest that the incisal edges of the maxillary central incisors should appear below the tips of the canines, creating a convex or consonant smile line.<sup>2</sup>

Although this confirms the importance of the upper central incisors in evaluating smile esthetics,<sup>1–3,5,6,9</sup> it also highlights a question: what is the most attractive vertical position of the upper central incisors, with respect to gingival contour and incisal edge, in the smile analysis? The methodology to clarify this question is difficult because when the vertical position of the upper centrals is altered, one is not only evaluating the position of the gingival margins but also the incisal edges. Kokich and colleagues<sup>14</sup> found that laypeople did not perceive a smile in which the gingival margins of the upper centrals were 1.5 mm below the line of the canines as unattractive. When the incisal edges were evaluated, the majority of studies found that a smile in which the central incisor edges are above the canine cusps, creating a reverse smile arc, are considered unattractive.

Although these studies assessed the position of the gingival margins and incisal edges independently, they did not account for the fact that vertically changing the position of these lines results in a modification of the crown length. The question that remains unanswered is: what is the most pleasing vertical position of the upper central incisors, taking into account both the

central incisor edges relative to the laterals and the central incisor gingival margins with respect to the canines. This information is of paramount importance because it can ultimately assist the clinician in optimizing smile esthetics.

The objective of this study was to assess the esthetic perceptions of orthodontists and laypeople with respect to different vertical positions of upper central incisors in a frontal smile analysis and to assess the role of gingival margins and incisal edges in this evaluation. The null hypothesis tested was that different vertical positions are rated as equally attractive by orthodontists and laypeople.

## MATERIALS AND METHODS

According to a pilot study, a sample size calculation was undertaken by using Bioestat (version 5.0). On the basis of significance level of alpha 0.01 and the effect size estimated at 0.95, the sample size was calculated to achieve 80% power. The sample size calculation showed that 54 subjects for each group were necessary.

A frontal close-up smile photo of a 27-year-old Caucasian female was selected for this study. The patient had no previous history of orthodontic treatment, and the smile exhibited unworn, unrestored, and healthy upper anterior teeth. According to some of the subjective principles of an ideal smile described in the literature,<sup>1–6</sup> this patient's smile would be considered highly attractive. These principles include: an adequate width/length proportion in the esthetic

zone; 1 mm of gingival display; gingival lines of the central incisors matching the canines, with the laterals 0.5 mm below; upper and lower dental midlines coincident; central-to-lateral incisal step of 1 mm and upper central crown length slightly longer than upper canines.<sup>30</sup>

The selected image was digitally altered using Adobe Photoshop CS3 (Adobe Systems, Inc., San Jose, CA, USA). The photo was manipulated to produce a symmetrical image (left to right) and was then retouched to adjust color, brightness, and contrast, as well as remove any discoloration in the lips and skin. The image was then condensed to achieve an image with measurements identical to those on the actual patient. Thus, each millimeter measured on the digital and printed image was equivalent to each millimeter measured clinically on the patient, using the upper central incisor as a reference. Furthermore, following recommendations from previous literature, a great part of the nose and chin was removed to reduce the number of variables on the images.<sup>14–17,25</sup>

After, the gingival line between the central incisors and the canines was used as a reference to extrude or intrude upper centrals in 0.5 mm increments, yielding a total of six smiles to be analyzed, referred to as the "full smile" group (Table 1 and Figure 1). These images were then cropped at the level of the lateral incisor edges to create a group of photos referred to as "gingival close-up" (Figure 2). Finally, the "full smile" images were also cropped at the level of the lateral incisor gingival margins creating a group called "incisal close-up" (Figure 3).

**TABLE 1.** Characteristics of the smiles used in this study

Altered vertical positions	Central gingiva margins	Central incisor edges
A: 0	Matching the canines	1.0 mm below the laterals
B: 0.5 mm extruded	0.5 mm below the canines	1.5 mm below the laterals
C: 1.0 mm extruded	1.0 mm below the canines	2.0 mm below the laterals
D: 1.5 mm extruded	1.5 mm below the canines	2.5 mm below the laterals
E: 0.5 mm intruded	0.5 mm above the canines	0.5 mm below the laterals
F: 1.0 mm intruded	1.0 mm above the canines	Matching the laterals



**FIGURE 1.** Full smile view in 0.5-mm altered vertical positions increments: A, unaltered; B, 0.5 mm extruded; C, 1.0 mm extruded; D, 1.5 mm extruded; E, 0.5 mm intruded and; F, 1.0 mm intruded.



**FIGURE 2.** Incisal close-up view in 0.5-mm altered vertical positions increments: A, unaltered; B, 0.5 mm extruded; C, 1.0 mm extruded; D, 1.5 mm extruded; E, 0.5 mm intruded; and F, 1.0 mm intruded.

Final images were digital files with 300 dpi (dots per inch) resolution. They were professionally printed using specialized digital equipment on standard A4 size format (29.7 cm × 42 cm). Then, a photo album was assembled containing all images from each group in random order.

The album was given to 120 judges: 60 orthodontists (37 male and 23 female) and 60 laypeople (32 male and 28 female) with a college education but no dental background. Each rater was given brief information about the study and was asked to evaluate the

attractiveness of the images. Along with the album, each judge received a form with 100-mm visual analog scales printed for each image, as in previous studies.<sup>10,13–17,21–23,28</sup> The scale ranged from “very unattractive” on the far left to “very attractive” at the far right. A line was also printed at the midpoint of each scale to provide a reference line for an average level of attractiveness. All judges marked a point along the scale according to their perception of smile esthetics. The scores were then measured in millimeters by the first author with an electronic digital caliper (Starrett, Suzhou, China).



**FIGURE 3.** Gingiva close-up view in 0.5-mm altered vertical positions increments: A, unaltered; B, 0.5 mm extruded; C, 1.0 mm extruded; D, 1.5 mm extruded; E, 0.5 mm intruded; and F, 1.0 mm intruded.

In order to assess the reliability of the method, six raters from each group were randomly selected. They were asked to evaluate one page of the album in which there was two identical images. Correlation coefficients were used to compare the scores for those images in order to determine intrarater agreement. High levels of reliability were found because all coefficients were greater than or equal to 0.71 for both group of raters.

The data were submitted to statistical analyses with the software SPSS 16.0 (Statistical Package for Social Sciences; SPSS, Inc., Chicago, IL, USA). Descriptive statistics were reported as means and standard deviations. Differences in the mean esthetic scores in the six levels of asymmetries were analyzed by using one-way analysis of variance with the Tukey post-hoc test. In order to compare the distributions of the mean scores between orthodontists and laypersons, the Student's *t* test was used. The level of significance was established at 5%.

## RESULTS

From the orthodontists' standpoint, the most attractive smiles were those in which the central incisor was extruded 0.5 mm (mean VAS score 85.13) and the original, unaltered position (mean 76.58). Orthodontists rated as least attractive the smile in which the central incisor was intruded 1.0 mm (mean 19.9). According to laypeople, the most attractive smiles were those with

the central incisor extruded 0.5 mm (mean 86.27), the original, unaltered position (mean 80.2), and the central incisor extruded 1.0 mm (mean 77.1). The least attractive smile according to laypeople was the one in which the central incisor was intruded 1.0 mm (mean 39.6) (Table 2).

Analysis of the "incisal close-up" images revealed that according to orthodontists, the most attractive smiles were those in which the central incisors were extruded 0.5 mm (mean 84.54), the original, unaltered position (mean 79.53), and the central incisors extruded 1.0 mm (mean 73.28). The smile rated as least attractive was the one in which the central incisors were intruded 1.0 mm (mean 22.72). Similar to orthodontists, laypeople considered the original position, the 0.5 mm extruded, and the 1.0 mm extruded positions as most attractive, and the 1.0 mm intruded and 1.5 mm extruded positions as least attractive (Table 3). Furthermore, in three images, statistical tests revealed that they were ranked in two different categories at the same time. For instance, the unaltered image was ranked in first place (similar to the 0.5 mm extruded smile) and second place.

The evaluation of "gingiva close-up" smiles was not coincident between orthodontists and laypeople. Orthodontists rated as most attractive the smile in which the central incisor was located extruded 0.5 mm, the original position, and the 1.0 mm extruded position, whereas they rated as least attractive the 1.0 mm intruded smile. On the other hand,

**TABLE 2.** Orthodontists' and laypersons' perception in the "full smile"

Altered vertical positions "full smile"	Orthodontists			Laypersons			Difference <sup>†</sup>
	Mean	SD	Results*	Mean	SD	Results*	
0	76.58	12.92	A	80.2	13.2	A	
0.5 mm extruded	85.13	6.93	A	86.27	9.79	A	
1.0 mm extruded	66.83	16.34	B	77.1	13.3	A	
1.5 mm extruded	46.56	15.56	C	61.18	15.56	B	
0.5 mm intruded	34.23	15.87	C	60.91	14.9	B	*
1.0 mm intruded	19.9	14.76	D	39.6	12.61	C	*

\*Smiles with the same letter did not differ from each other.  
<sup>†</sup>Statistical difference between the two group of raters ( $p < 0.05$ ).

**TABLE 3.** Orthodontists' and laypersons' perception in the "incisal close-up" smile

Altered vertical positions "incisal close-up"	Orthodontists			Laypersons			Difference <sup>†</sup>
	Mean	SD	Results*	Mean	SD	Results*	
0	79.53	14.07	A	74.15	18.23	A,B	
0.5 mm extruded	84.54	9.83	A	84.63	12.45	A	
1.0 mm extruded	73.28	15.69	A	76.02	12.46	A,B	
1.5 mm extruded	46.5	14.28	B	59.62	23.33	B,C	*
0.5 mm intruded	43.57	16.92	B	70.27	14.88	B	*
1.0 mm intruded	22.72	16.64	C	51.12	17.52	C	*

SD = standard deviation.  
 \*Smiles with the same letter did not differ from each other.  
<sup>†</sup>Statistical difference between the two group of raters ( $p < 0.05$ ).

laypeople showed no statistical difference among all smiles when evaluating the "gingival close-up" (Table 4).

The comparison between both groups of raters showed statistical differences in some situations where laypersons were more tolerant, ranking the smiles with higher scores (Tables 2–4).

## DISCUSSION

The upper central incisors are the key determinant in evaluating smile esthetics, and thus, their vertical

positioning is an aspect of paramount importance.<sup>1–3,5,6,9</sup> Their vertical placement has implications on different areas such as anterior esthetic restorations, anterior veneer placements, setting of dentures, and orthodontic bracket positioning. Based on the importance of the upper central incisors in evaluating smile esthetics, it is recommended that any treatment plan with an emphasis on esthetics must begin at the upper central incisor area.<sup>1,3,6</sup>

According to a frequently cited guideline, the gingival margins of the central incisors should match the canines, and the gingival margins of the lateral incisors should be slightly below that level.<sup>1–3,5–8</sup> Although a

**TABLE 4.** Orthodontists' and laypersons' perception in the "gingival close-up" smile

Altered vertical positions "gingiva close-up"	Orthodontists			Laypersons			Difference <sup>†</sup>
	Mean	SD	Results*	Mean	SD	Results*	
0	77.56	16.23	A	78.55	15.87	A	
0.5 mm extruded	76.1	11.97	A	75.01	16.26	A	
1.0 mm extruded	73.4	11.47	A	72.32	19.76	A	
1.5 mm extruded	39.89	15.48	B	63.74	22.71	A	*
0.5 mm intruded	40.32	14.92	B	63.61	21.69	A	*
1.0 mm intruded	23.86	15.05	C	66.57	19.01	A	*

SD = standard deviation.  
 \*Smiles with the same letter did not differ from each other.  
 †Statistical difference between the two group of raters ( $p < 0.05$ ).

great number of esthetic treatment plans are based on this clinical recommendation, evidence-based studies supporting it are scarce. Charruel and colleagues evaluated 103 young adults with healthy anterior dentition in order to assess the relationship between the gingival margins of the maxillary centrals, laterals, and canines. They did not corroborate the frequently cited recommendation but rather found that the ideal position of the central incisor gingival margins is located below the line tangent to the canine's gingival margins.<sup>31</sup>

The methodology to clarify this issue is somewhat difficult because when the vertical position of the upper central incisors is altered, one is not only evaluating the position of the gingival margins but also the incisal edges. Some studies have been conducted to evaluate the threshold for the presence of gingival asymmetries between centrals and laterals,<sup>14–16,19</sup> and also to determine the ideal central-to-lateral incisal step.<sup>19,27</sup> However, these studies did not account for the fact that altering the gingival margins and incisal edges also alters tooth proportions. Ideally, in order to determine the perception of an individual characteristic, it is necessary to isolate only that characteristic during the evaluation process. Thus, we separated the analysis into "full smile," "incisal close-up," and "gingival close-up" in order to quantify the role of gingival margins and incisal edges in the overall perception of smile esthetics.

Analysis of the data from our study showed that in the "full smile" analysis, the smile that had the highest score was the one in which the central incisor gingival margins matched the lateral incisor margins, and both were 0.5 mm below the canine margins (Table 2). This setup also displayed no statistical difference from the original smile where the gingival margins of the central incisors matched the canines, and the gingival margins of the lateral incisors were slightly below. The most preferred central-to-lateral incisal step was 1.0 to 1.5 mm. It was also found that the least attractive smile in the "full smile" appraisal was the one in which the central incisors were intruded 1.0 mm from the original. This information shows that a smile that displayed no step between centrals and laterals in conjunction with the central incisors gingival margins above the canines' was perceived as unesthetic. This finding is corroborated by a recent systematic literature review, which found that laypeople preferred consonant smile arcs when compared with flat smiles.<sup>32</sup>

The evaluation of the cropped images showing the incisal edges arrangement yielded similar results to the "full smile" images. This similarity highlights the role of the incisal edges in the overall smile esthetics. For both groups of raters, the most attractive central-to-lateral incisal steps were 1.0, 1.5, and 2.0 mm, with no statistical difference among them (Table 3). The least attractive incisal edge relationship

was the one with no step. The preference for greater steps between centrals and laterals is confirmed by Ker and colleagues<sup>19</sup> who found an ideal step to be 1.4 mm. On the other hand, King and colleagues<sup>27</sup> found that the most attractive central-to-lateral incisal step was 0.6 mm. Given the great variability in perception of this variable, communication with the patient is essential during the treatment planning process.

On the other hand, evaluation of the cropped images showing only the altered gingival margin arrangement yielded different results. For laypeople, no statistical difference was found among all smiles, suggesting that gingival margins play only a small role in the overall perception of smile esthetics. Our findings are supported by literature reporting large thresholds for gingival margin discrepancies.<sup>14–16,19</sup> Some studies have shown that when there is a gingival margin discrepancy between central and lateral incisors, neither laypeople nor dental professionals considered a 2 mm discrepancy unesthetic.<sup>15,19</sup> Others added that when the gingival margin discrepancy was between the central incisors, a discrepancy of 0.5 mm and 1.5 mm was considered unattractive by orthodontists and laypersons, respectively.<sup>15,16</sup>

This comparison of the role of gingival margins and incisal edges in the overall perception of smile esthetics has a profound impact on clinical decision making. According to our findings, gingival margins have a weak correlation with overall perception of smile esthetics, and thus, the question whether the maxillary central incisor gingival margins should match the canines' or should be slightly below becomes less important. On the other hand, the incisal edges showed a strong correlation with the overall smile esthetics analysis. Ultimately, the contour of the incisal edges is the single most important variable in perception of smile esthetics.<sup>15</sup>

With this in mind, when deciding upon the ideal vertical position of the upper central incisors in a given case, the clinician should give more priority to proper positioning of the incisal edges instead of gingival asymmetries. Based on the data of our paper and

previous studies,<sup>14–16,19</sup> orthodontists and laypeople are more tolerant to gingival asymmetries than incisal edge discrepancies. Thus, because the threshold for gingival asymmetry is large, it makes more sense to emphasize an ideal central-to-lateral incisal step.

The assessment of the upper anterior dentition crown lengths becomes very important because of its correlation with the vertical position and the incisal display during smiling. For instance, literature shows that upper centrals length is greater than canines,<sup>30</sup> and thus, if the centrals gingival margins matches the canines, upper centrals may be properly positioned in the vertical dimension. On the other hand, if any tooth wear is present in the upper centrals, it may result in a diminished crown length and may compromise the incisal edges relation. Ultimately, if a clinician strictly follows the guideline suggesting that the central incisor gingival margins should match the canines and do not evaluate upper central incisors length and the incisal edges position compared with the canines, one may create a smile in which the upper central incisor edges are above those of the canines, creating a flat, reverse, or nonconsonant smile.<sup>8,13,20,28</sup>

On the other hand, if proper upper centrals vertical position and crown length is achieved with emphasis on its incisal edges being located below the tips of the canines, a convex, or consonant, smile is achieved.<sup>2</sup> Clinically, the position of the incisal edges should follow the lower lip,<sup>1–3,6,7</sup> and thus, this aspect needs to be evaluated to assist in the placement of the upper central incisor edges.

Another aspect that needs to be evaluated when modifying vertical position of the upper central incisors is the mandibular function. It is clear that extruding or intruding those teeth may influence mandibular lateral excursive and protrusive movements. Therefore, before making any vertical modification in upper centrals to optimize smile esthetics, the mandibular function should be carefully checked, and also, possible occlusal adjustments may be necessary.

In this study, we surveyed orthodontists and laypeople. The first group was selected because previous studies



showed that they are the most sensitive group in detecting deviations from ideal.<sup>13–18,20,23</sup> The latter was chosen because they are the primary consumers of dental services, instead of practitioners, who are providers of care.<sup>19</sup> Following the tendency seen in the literature, these examiners showed different esthetics perceptions.<sup>13–18</sup> In most situations, orthodontists were more critical in their evaluation. However, for the most attractive smiles, both groups displayed no statistical difference. It can be hypothesized that an ideal smile arrangement can easily be recognized by any group of raters, but when smaller deviations are included, they start to show differences in their judgment.

The main difference between orthodontists and laypersons was their threshold for gingival margin and incisal edge position. For the orthodontists, in the “full smile” appraisal, a 0.5 mm gingival margin deviation was considered within normal limits, whereas for the laypersons, the threshold was 1.0 mm. At the same time, the orthodontists’ threshold for central-to-lateral incisal step was 0.5 and 1.0 mm for laypersons. Those results suggest that the treatment of minor vertical position discrepancies might reflect an exaggerated concern by dental specialists rather than an esthetic need.<sup>16</sup>

Finally, it is important to remember that because this study used computer-manipulated smile images from one female patient and the opinion of specific groups of individuals, the results should be carefully analyzed. As stated by Kokich and colleagues,<sup>15</sup> because the results and conclusions are based on averages, it is difficult to customize this information to a patient because of the subjectivity in evaluating smile esthetics. In addition, upper central incisor positioning is influenced by many variables, including age, sex, tooth anatomy, upper and lower design, etc. Therefore, the ideas proposed in this study should be carefully discussed with patients before deciding upon the most attractive central incisors vertical position for a given patient.

## CONCLUSIONS

The outcomes of this study demonstrate the following.

- 1 The highest rated smiles showed two notable characteristics: the central-to-lateral incisal step was 1.5 mm; and the central incisor gingival margins matched the laterals, and both were 0.5 mm below the line of the canine gingival margins. This smile type did not differ statistically from the one with a central-to-lateral incisal step of 1.0 mm and with the central incisor gingival margins matching the canines.
- 2 The least attractive smile was the one with no step between the centrals and laterals, and with the central incisor gingival margins 1.0 mm above the canine gingival margins.
- 3 The analysis of the three types of views indicates that gingival margins have minimal impact on the overall perception of smile esthetics, whereas the incisal edge relationship plays an important role in the overall analysis of smile esthetics.
- 4 It can be hypothesized that an ideal smile arrangement can easily be recognized by any group of raters, but when smaller deviations are included, they start to show differences in their judgments.

## DISCLOSURE

The authors do not have any financial interest in the companies whose materials are included in this article. I sign for and accept responsibility for releasing this material on behalf of *any* and all coauthors.

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Funding from CAPES/Brazil Bex: 4832/10-8

This article is accompanied by commentary, "Influence of the Vertical Position of Maxillary Central Incisors on the Perception of Smile Esthetics Among Orthodontists and Laypersons," Vishnu Raj, BDS, MSFS, MS, DOI 10.1111/jerd.12057