Smile esthetics from the layperson's perspective

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Introduction: Computer-based smile esthetic surveys based on slider technology allow more precise control of variables and the possibility of obtaining continuous data. Variations in the perception of smiles from different facial perspectives have not been resolved. The objective of this study was to quantify the ideal and the range of acceptable values for smile variables judged by laypersons from a full-face perspective for comparison with lower-face data. **Methods:** Mirrored and symmetric male and female full faces previously determined by peers to be of average attractiveness were used. Ninety-six laypersons judged these smile variables: smile arc, buccal corridor fill, maxillary gingival display, maxillary midline to face, maxillary to mandibular midline discrepancy, overbite, central incisor gingival margin discrepancy, maxillary anterior gingival height discrepancy, incisal edge discrepancy, and cant. The judges manipulated the variables using adjustable image technology that allowed the variable to morph and appear continuous on a computer monitor. Medians for each smile variable were compiled, and the Fleiss-Cohen weighted kappa statistic was calculated to measure reliability. Multiple randomization tests with adjusted *P* values were used to compare these data with those for lower-face views. **Results:** Reliability ranged from 0.25 for ideal overbite to 0.60 for upper midline to face, except for upper and lower buccal corridor limits, which each had a kappa value near 0. There were no statistically significant differences between the ratings of male and female raters. The following variables showed statistically and clinically significant differences (>1 mm) when compared with the lower-face view: ideal smile arc, ideal buccal corridor, maximum gingival display, upper to lower midline, and occlusal cant. Although the smile arc values differed because of model lip curvature variations, the principle of tracking the curve of the lower lip was confirmed. For the full-face view, the raters preferred less maximum gingival display, less buccal corridor, more upper to lower midline discrepancy, and less cant of the occlusal plane. **Conclusions:** Reliability was fair to moderate with the exception of the buccal corridor limits. Most variables showed no clinically meaningful differences from the lower-face view. The acceptable range was quite large for most variables. Detailed knowledge of the ideal values of the various variables is important and can be incorporated into orthodontic treatment to produce an optimal esthetic smile. (Am J Orthod Dentofacial Orthop 2011;139:e91-e101)

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Smile esthetics has become a central concern for patients and orthodontists because this is a primary reason that patients seek orthodontic treatment, and orthodontists are now using this as a focus for treatment planning.[1,2] Investigation of the variables that contribute to esthetic smiles began in a controlled manner with the innovative study of Kokich et al.[3] Using altered photographs with only the lips and teeth visible to fabricate 5 variations of 8 variables, they asked participants to rate the attractiveness of the altered images on a visual analog scale (VAS). They found that laypersons, dentists, and orthodontists detected changes in smile characteristics at different threshold levels, and that laypersons were the most forgiving. This study began to define values for the smile variables. One drawback of the study of Kokich et al was the large increments they used to alter the images—in some cases, 2 mm between images. This made detection of small differences impossible and also left open the possibility that the true value for the variable was between the choices offered.

Johnston et al[4] also showed a difference between orthodontists' and laypersons' ratings. These differences highlight the importance of focusing on what the patients want regarding orthodontic treatment, since they ultimately must be satisfied as long as their goals are within a clinically acceptable range.

The study of smile variables was advanced by using more sophisticated digital image manipulation and computer-based methodologies. Parekh et al[5,6] studied smile arcs and buccal corridors, with raters viewing a series of incremental photographs with different combinations of ideal, decreased, and increased smile arcs and buccal corridors and made judgments regarding the ideal and the range of acceptable options for each variable. In the pilot study for this work, Parekh et al[5] used a creative slider technology. This was a method of linking a slider to an oral image so that moving the slider altered selected portions of the image. The raters (all orthodontists) were asked to move the slider to choose the image representing the ideal smile.

Ker et al[7] also used the slider method to study smile variables and were the first to use sliders for a full survey with lay raters. This technology allowed the raters to manipulate the variables themselves through a seamless range of possibilities and to choose the ideal and the acceptable limits instead of merely judging preselected images. The slider also was a change from the traditional use of a VAS to quantify esthetic judgments. A VAS is well established and considered valid and reliable.[8] It is a subjective rating of the variable, and it is anchored to concrete concepts to make it valid. The slider allowed raters to view a large series of photographs quickly and choose the ideal easily. This was an efficient design that presented a wider range of possible choices in a shorter time and allowed a more precise selection.

Ker et al[7] also used the lower-face perspective to compare their data with those of Parekh et al[5,6] for oral image data while expanding the number of variables investigated. Ker et al looked at the following variables: buccal corridor fill, smile arc, maxillary anterior gingival height discrepancy, maxillary gingival display, incisal edge discrepancy, overbite, central incisor gingival margin discrepancy, canine torque in broad and narrow smiles, posterior crown torque in narrow and broad smiles, maxillary central incisor crown width to height ratio, maxillary lateral to central incisal ratio, maxillary midline to face, maxillary to mandibular midline discrepancy, and cant. Their study refined or defined the ideal for each of these variables and also a range within which the raters still considered the images to be acceptable. It is important to note the difference between ideal and acceptable. An acceptable range of values would be useful to clinicians in evaluating the smiles of their patients, especially for understanding that we cannot always achieve the ideal.

There are few studies of smile characteristics with a full-face perspective. The full-face perspective mimics views encountered in normal conversation in contrast to the lower-face and oral views. This wider perspective could dilute or de-emphasize the attention to the details of the smile. For example, a change in a variable will be much smaller relative to the overall image when viewing a full face rather than just the lower face. That appears to be the case as shown by the study of Flores-Mir et al,[9] in which the esthetic impact of the anterior dental occlusion was less in the full-face view compared with the dental or lower-face views. This study also demonstrated significant variations by patient, most likely because of the model's facial appearance.

Havens et al[10] showed that photos of a malocclusion with a full-face view were more attractive than the same malocclusion shown as a circumoral view. Their theory was that the perspective of the face helped camouflage the unattractive oral area. Conversely, when Rodrigues et al[11] showed people a series of photos with changes in smile arc, maxillary lateral incisor tip, midline diastema, and midline deviation, the perspective made no difference on their rankings.

The oral-view data of Parekh et al[5] appeared similar to those of Moore et al[12] with full-face perspective data for buccal corridors, but they were different from those of the lower-face view of Ker et al.[7] Certainly, perspective has yielded contrasting results.

Shaw et al[13] argued that overall facial attractiveness was more important than dental esthetics in overall esthetics. It is possible that the attractiveness of the face alters the importance of the smile characteristics and that the background attractiveness of the face must be accounted for and controlled so that this variable does not inadvertently bias the results.

The purpose of this study was to quantify smile variables from a layperson's point of view with full-face images of models of average attractiveness. These data were compared with the same variables viewed from the lower-face perspective to determine the effect of perspective and further validate existing smile esthetics data.

MATERIAL AND METHODS

The general method of this computer-based survey was to digitally modify 1 smile so that raters could evaluate the ideal and the acceptable range of several important smile characteristics, measured in the context of male and female full-face perspective images. The design was approved by the institutional review board of Ohio State University.

Table I. Esthetic variables examined[7]

Variable	*Description*	*Range*
Smile arc	The curvature formed by an imaginary line tangent to the incisal edges of the teeth, modified in varying degrees of curvature in relationship to the lower lip.	From no curvature to an accentuated curvature. The degree of curvature was in relation to the lower lip, so quantification differed for each model.
Buccal corridor fill	The amount of dark space displayed between the facial surfaces of the posterior teeth and the corners of the mouth, calculated as the total dark space on both sides of the mouth as a percentage of the total smile width.	From 6% to 26.5% in approximately 0.5% increments.
Maxillary gingival display or gummy smile	The amount of gingival show above the central incisor crowns and below the center of the upper lip. Negative numbers indicate gingival exposure; positive numbers indicate tooth overlap by the lip.	From 1 mm of gingival display (−1) to almost 7 mm of tooth coverage for the female model, and approximately 2 mm of gingival display (−2) to 6 mm tooth coverage for the male model in approximately 0.25-mm increments. The variation between models was due to differences in sizing and coordinating the images for different faces.
Maxillary midline to face	The relationship of the maxillary dental midline (measured between the central incisors) to the midline of the face, defined by the center of the philtrum and the facial midline.By definition, the ideal was considered to be 0 for this variable.	The maxillary midline was moved to the left of the face in approximately 0.25-mm increments. The right and left buccal corridors were maintained throughout the movement of the dentition.The maximum deviation shown was 6 mm.
Maxillary to mandibular midline	The relationship of the maxillary central to the central embrasure to the mandibular central to central embrasure.By definition, the ideal was considered to be 0 for this variable.	Maintaining the maxillary midline, the mandibular dentition was moved to the left in approximately 0.25-mm increments. The right and left buccal corridors were maintained throughout the movement of the mandibular dentition. The maximum deviation shown was 5.5 mm.
Overbite	The vertical overlap of the central incisors measured in both millimeters of coverage and percentage of coverage of the mandibular incisor.[13] This was modified by incrementally altering the mandibular layer of the image in the vertical dimension. The vertical movement of the mandibular layer produced an increased or a decreased overbite.	The layer was moved in approximately 0.25-mm increments. The range was from 0 to 9 mm of overbite (or 100%).
Central incisor gingival margin discrepancy	The vertical gingival margin difference between the central incisors. By definition, the ideal was considered to be 0 for this variable.	The gingival margin of the left maxillary central incisor was altered in approximately 0.25-mm increments. The incisal edges were maintained at their original height. The maximum deviation was 3 mm.
Maxillary anterior gingival height discrepancy from central to lateral incisor	The difference in the vertical height of the gingival zenith of the central incisor to the lateral incisor. A negative value indicated that the lateral incisor gingival margin was incisal to the central incisor gingival margin; a positive value indicated that the lateral incisor gingival margin was apical to the central incisor.	Variations from increased to decreased height were presented in approximately 0.25-mm increments.The range was −2.6 to almost 1 mm.
Incisal edge discrepancy or lateral step	The vertical difference between the incisal edges of the central and lateral incisors.	Variation was assessed by moving both lateral incisors up or down together in approximately 0.25-mm increments. The range was 0.4 to 2.4 mm.

Table I. Continued

Variable	*Description*	*Range*
Cant	The divergence of the occlusal plane from the horizontal axis, as seen when smiling, was altered by gradually rotating the plane through a point between the central incisors. By definition, the ideal was considered to be 0 for this variable.	The rotation of the plane occurred in 0.25° increments. The range was 0° to 6°.

Raters were recruited from a poster displayed in a central campus facility. Those who were interested approached the investigators for more information; no raters were solicited. The raters were first given a script that briefly explained the study. Inclusion criteria required participants to be conversant in English and familiar with using a mouse to control a computer. They consented to participate by completing the study and providing optional demographic data (age and sex). Dental professionals and dentistry and dental hygiene students were excluded.

Photographs of faces of consenting young adults were digitally bisected, mirrored, and sized for the survey by using a photo editing program, Photoshop CS3 (version 10, Adobe, San Jose, Calif). These photographs were acquired from a database of facial images previously rated by peers to be of average attractiveness. This was accomplished by having young adults rate bisected and mirrored smiling frontal facial photographs of volunteer young adult models using a VAS scale anchored with "very attractive" and "very unattractive." Faces with mean VAS values from the central 20% of the scale were used. Faces of average attractiveness were used to prevent any uncontrolled influence from the background attractiveness of the model. One female and 1 male face were selected.

A similar method was used to generate a set of symmetrical and esthetic teeth placed in the lip profile of the full-face images. An intraoral photograph of a completed orthodontic patient was bisected, mirrored, and reassembled to form a smile that was sized to fit the mouth by using Photoshop CS2. For each variable measured, sequential layers of the same smile were altered by using templates of teeth digitally separated from the initial image. Once a series of modification values was established that appeared to represent the range of visually realistic smiles, the tooth images were stored as sequences that showed small incremental changes in 1 variable that was suitable for combination with any of the facial images to create a finished stimulus model for rating.[7] The variables examined in the study are described with the range of variations in Table I.

The following were the dependent variables in this study.

1. Esthetic attractiveness of each variable: the perception of esthetics was based on the raters' response to the instruction, "please adjust the slider below to the ideal image." Smile characteristics could be adjusted by positioning a slider to a rater-determined ideal position. Each image was assigned a known value based on the deviation from the original image.
2. Acceptability: in separate images, the raters were then asked to select the position of the slider corresponding to increasing and decreasing the variable of interest relative to the ideal point identified by previous research.[7] They were instructed to move the slider until the image became unattractive. By completing this exercise, they defined the limits of acceptability. Each image was assigned a known value based on the deviation from the original image.

Data were collected on a stand-alone laptop computer via a customized program running in MATLAB (Mathworks, Natick, Mass), a numeric computing environment and programming language software. The program randomly displayed a single face image with teeth and allowed the participant to use the mouse to adjust an on-screen slider according to the displayed instructions to choose the ideal image or the acceptable limit. The slider motion triggered changes in the tooth image displayed, allowing the participant to adjust through the full sequence of tooth images for 1 variable at a time. The increments were small enough between successive images to produce the illusion of continuous variation as the slider was moved. Every image for each variable had a number assigned to it that was identified by the program as the choice and saved as data by image number. The image numbers were translated to values that represented the modification value of that smile characteristic.

Of the 10 variables, 6 had 3 questions associated with them: choose the ideal image, the upper limit, and the

Table II. Reliability measured by Fleiss-Cohen weighted kappa statistic

Measure	K_W	$LCI_{.95}$	$UCI_{.95}$	*Interpretation*
Ideal smile arc	0.34	0.25	0.43	Fair
Maximum smile arc	0.31	0.22	0.41	Fair
Minimum smile arc	0.30	0.20	0.40	Fair
Ideal buccal corridor	0.36	0.26	0.45	Fair
Minimum buccal corridor	0.09	0.06	0.14	Slight
Maximum buccal corridor	0.03	−0.02	0.09	Slight
Ideal gingival display	0.49	0.41	0.56	Moderate
Minimum gingival display	0.58	0.52	0.64	Moderate
Maximum gingival display	0.46	0.38	0.55	Moderate
Upper midline to face	0.60	0.53	0.67	Moderate
Upper to lower midline	0.48	0.40	0.57	Moderate
Ideal overbite	0.25	0.13	0.38	Fair
Minimum overbite	0.34	0.25	0.43	Fair
Maximum overbite	0.45	0.37	0.54	Moderate
Central to central gingiva	0.58	0.51	0.66	Moderate
Ideal central to lateral gingiva	0.35	0.25	0.44	Fair
Minimum central to lateral gingiva	0.48	0.40	0.55	Moderate
Maximum central to lateral gingiva	0.38	0.29	0.47	Fair
Ideal central to lateral step	0.30	0.21	0.39	Fair
Maximum central to lateral step	0.44	0.37	0.52	Moderate
Maximum cant	0.53	0.45	0.61	Moderate

lower limit. These were buccal corridor fill, smile arc, maxillary anterior gingival height discrepancy, maxillary gingival display, incisal edge discrepancy, and overbite. The other 4 had only 1 question: deviation from 0, because the ideal was defined as no deviation. These were central incisor gingival margin discrepancy, maxillary midline to face, maxillary to mandibular midline discrepancy, and cant. Each question was asked twice to assess the rater's reliability.

To make the length of the survey manageable, the variables were divided into 6 surveys. Each variable was viewed completely by 1 group of raters (96 raters per variable according to the power analysis below). Surveys 1 through 4 included 2 variables and asked all questions for those variables. Surveys 5 and 6 included only 1 variable. It took most participants 10 to 15 minutes to complete 1 of these surveys. Each participant was compensated with a $10 gift card.

Statistical analysis

A power analysis was performed to determine the sample size. Of the dependent variables in this study, overbite was reported by Ker et al[7] to have the highest variance, so it was used to determine the sample size. With a nondirectional alpha risk of 0.05 and assuming a standard deviation of 3.5, a sample size of 87 subjects was needed to detect a difference of ±1.5 mm with a power of 0.86.[7] Ten percent was added to this sample size in case nonparametric analysis would be needed. As a result, the final sample size per variable was 96 subjects. With a sample size of 96 for each variable and 6 surveys, a total of 576 participants were required.

Median data were compiled, and a Fleiss-Cohen weighted kappa statistic (K_W) was used to confirm reliability. Multiple randomization tests with P values adjusted by using the step-down Bonferroni method of Holm were used to compare the data with those of Ker et al.[7]

RESULTS

The raters were 51% male and 49% female. Their ages ranged from 18 to 72, with a mean age of 25.

The reliability statistics for our 10 variables ranged from 0.25 for ideal overbite to 0.60 for upper midline to face, except for the acceptable upper and lower limits of the buccal corridor, which both had a K_W close to 0 (Table II).

There were no statistically significant differences between the ratings of the male and female raters ($P > 0.13$).

The following variables showed statistically significant differences when compared with the lower-face view: ideal and maximum smile arcs, all 3 buccal corridor measures, maximum and minimum acceptable gingival display, acceptable upper midline to face, upper to lower

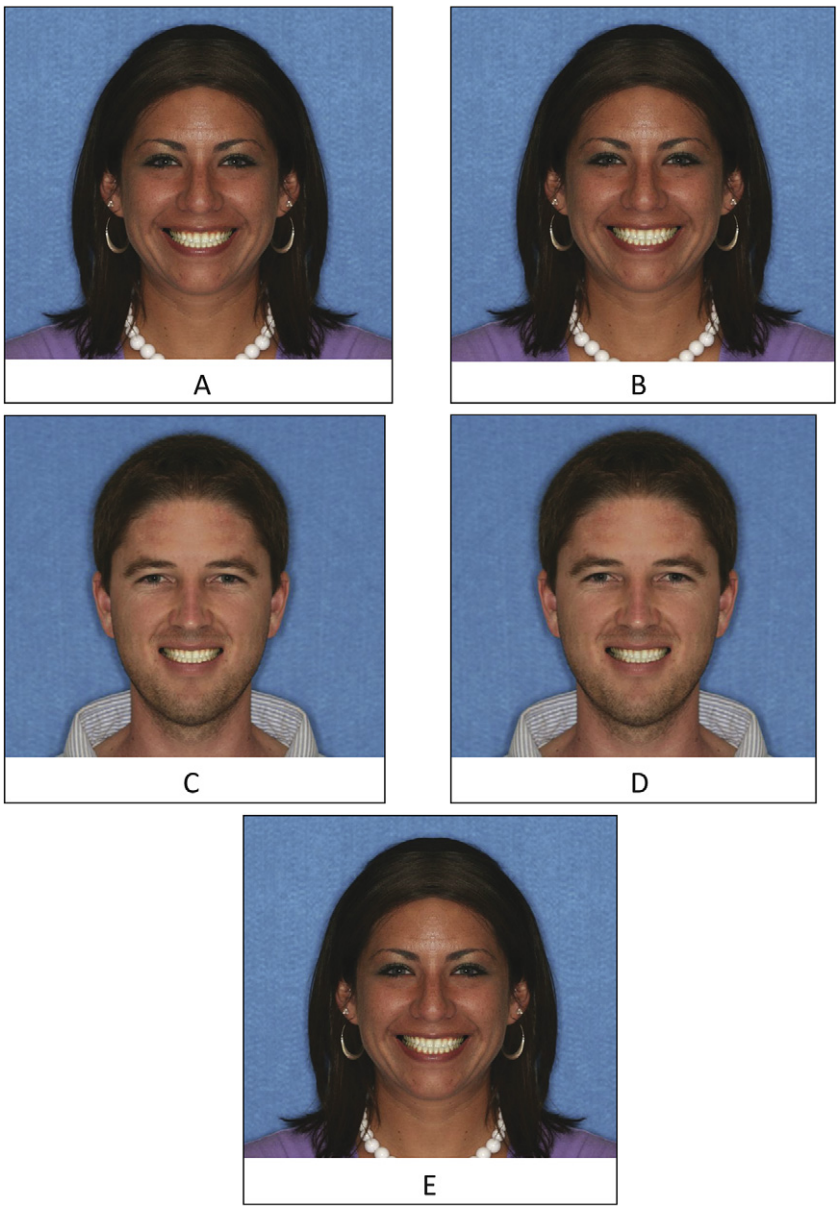

Fig 1. Images of the results of the ratings of the full-face perspective variables: **A**, the ideal smile arc is coincident with curvature of the lower lip; **B**, the ideal buccal corridors at a combined 13%; **C**, the ideal gingival display with 2.3 mm coverage of the central incisor; **D**, maximum acceptable upper midline to face deviation of 3.2 mm; **E**, maximum occlusal cant of 2.8.

midline deviation, minimum overbite, maximum and minimum acceptable lateral to central incisor gingival discrepancy, maximum and ideal lateral incisal step, and occlusal cant (Table III). In all but 5 cases (ideal smile arc, ideal buccal corridor, maximum gingival display, upper to lower midline, and occlusal cant), these differences were not considered clinically meaningful because of the small magnitude of the differences (either less than approximately 1 mm as measured or converted from percentages or degrees) and therefore similar to the lower-face perspective.

DISCUSSION

Reliability was fair to moderate for all measures except buccal corridor limits.[14] The complete lack of reliability for buccal corridor limits in the full-face perspective was unexpected. There are several possible explanations for the low buccal corridor coefficients. First, the

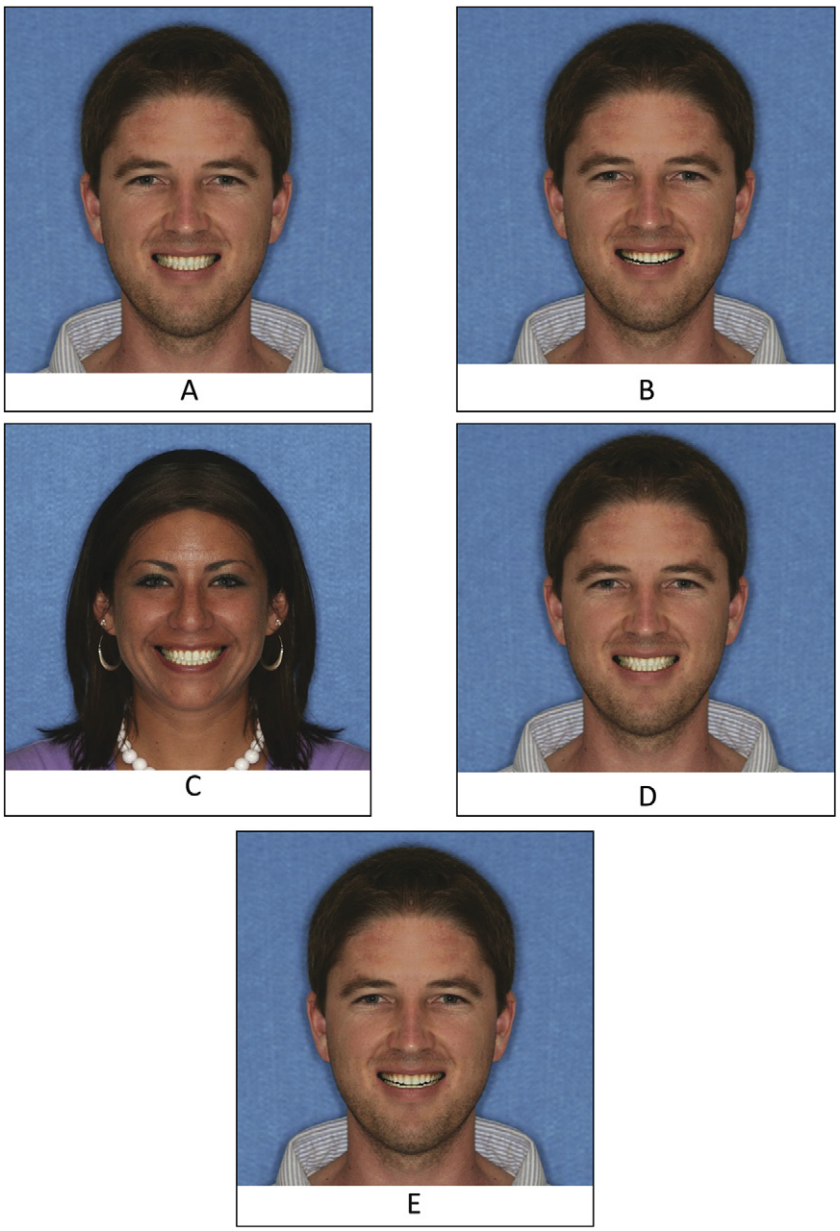

Fig 2. Images of the results of the ratings of the full-face perspective variables: **A**, maximum acceptable upper to lower midline deviation of 3.6 mm; **B**, maximum acceptable central incisor gingival deviation of 2.1 mm; **C**, ideal central to lateral gingival height difference of –0.4 mm; **D**, ideal overbite of 2.3 mm; **E**, ideal lateral step of 1.2 mm.

between-subject variance was low; this increases the contribution of the within-subject variance to the kappa statistic, thereby lowering the value. Second, buccal corridor measures had a relatively high number of categories, which also tended to lower the kappa statistic.[15] Finally, it could be the result of using a full-face view for the model. Previously, Ker et al,[7] using a lower-face view, and Parekh et al,[6] using an oral view, demonstrated higher reliability (K_W = 0.81 and K_W = 0.7, respectively). The full-face view might dilute attention to this detail. Moore et al[12] did not report reliability in their study, and no other studies have reported buccal corridor data in a full-face perspective.

No differences were found between male and female raters. This is consistent with the findings of Ker et al, Martin et al,[16] Dunn et al,[17] and Moore et al. With no

Table III. Summary values for full-face view and comparisons with lower-face values of Ker et al[5]

Variable	*n*	*Median*	*Lower 95% CI for median*	*Upper 95% CI for median*	*Minimum*	*Maximum*	*Δ*[†]	P *(adjusted)*[‡]
Ideal smile arc (mm)	187	−2.0	−2.5	−2.0	−6.0	4.0	−3.5	<0.0001
Maximum smile arc (mm)	182	−4.0	−4.5	−4.0	−6.0	3.0	1.0	0.26
Minimum smile arc (mm)	184	1.5	1.0	2.0	−6.0	4.0	−1.0	0.00
Ideal buccal corridor (%)	177	13	12	13	6	25	−4	<0.0001
Minimum buccal corridor (%)	180	17	16	19	6	27	9	<0.0001
Maximum buccal corridor (%)	175	17	16	18	7	27	−5	<0.0001
Ideal gingival display (mm)[§]	184	2.3	2.3	2.4	−1.1	5.6	0.1	1.0000
Minimum gingival display (mm)[§]	179	0.8	0.3	0.8	−1.9	3.0	4.4	<0.0001
Maximum gingival display (mm)	178	4.5	4.5	5.0	2.3	6.8	0.5	<0.0001
Upper midline to face (mm)*	185	3.2	3.0	3.6	1.1	5.7	0.2	0.01
Upper to lower midline (mm)*	157	3.6	3.5	3.8	1.1	5.7	1.6	<0.0001
Ideal overbite (mm)[‖]	179	2.3	2.3	2.4	0.0	6.2	0.2	1.0000
or as a percentage		31.5	31.5	32.9	0.0	84.9	2.7	
Minimum overbite (mm)	182	0.9	0.8	1.5	0.0	5.0	0.6	<0.0001
or as a percentage		12.3	11	20.5	0.0	68.5	8.2	
Maximum overbite (mm)	173	5.4	5.4	6.0	5.0	8.9	−0.3	0.88
or as a percentage		74	74	82	68.5	122	−4.1	
Central to central gingiva (mm)*	180	2.1	1.8	2.3	0.0	3.0	0.1	0.29
Ideal central to lateral gingiva (mm)[¶]	185	−0.4	−0.8	−0.4	−2.6	0.8	0.0	0.07
Minimum central to lateral gingiva (mm)[¶]	179	−1.9	−2.3	−1.9	−2.6	−1.1	1.0	<0.0001
Maximum central to lateral gingiva (mm)[¶]	183	0.4	0.4	0.4	−1.1	0.8	−0.8	<0.0001
Ideal central to lateral step (mm)	188	1.2	1.1	1.2	0.4	2.4	−0.2	<0.0001
Maximum central to lateral step (mm)	186	2.0	1.9	2.0	1.5	2.4	−1.0	<0.0001
Maximum cant (°)*	172	2.8	2.5	3.3	0.0	6.0	−1.5	<0.0001

*Ideal is defined as "0" for these variables; [†]Difference from median values of Ker et al[7]; [‡]Statistical comparison to median values of Ker et al[7]; [§]Negative values indicate gingival exposure; positive values indicate tooth crown overlap by the lip; [‖]Negative values indicate open bite; positive values indicate vertical overlap of the maxillary and mandibular teeth; [¶]Negative values indicate the lateral incisor gingival margin was incisal to the central incisor gingival margin; positive values indicate the lateral incisor gingival margin was apical to the central incisor.

differences between male and female raters, the data were combined for comparison with those of Ker et al.

Ker et al[7] used a sexually ambiguous image for their survey and therefore could make no comparisons between the sexes of their models. Because our data were compared with those of Ker et al, no sex comparisons were made.

The perspective of the image did not make a clinically significant difference for most variables. This was in part due to the arbitrary decision that differences should exceed 1 mm between full-face and lower-face ratings to be considered clinically significant.

Past research showed that people look other places first and longer than the teeth when viewing a smiling face.[3,18] It seems logical that the esthetic effect of the smile would be diluted when it is presented in a full face, so that it is somewhat surprising to see few clinically significant differences in the full-face smile study compared with lower-face view.[7] One potential distraction was the attractiveness of the face. This variable was managed by selecting models of average attractiveness and standardizing it throughout the survey.

A possible reason that so few differences were found was the nature of our survey. Allowing raters to manipulate the variables themselves drew their attention to those variables. This could have caused the smile to be the focus of the rating to the exclusion of background facial features. Global rating of faces might combat this problem and provide different results, but it would then resort to incremental and less precise evaluations of the variables.

Although the dental variables evaluated by the raters were identical for the full-face and comparison lower-face perspectives, those images did not have identical surrounding facial contexts, with only a change in perspectives. Ker et al[7] used a sexually ambiguous model, and the full-face models were sex-specific.

Of all the statistically significant differences we found, only 5 were deemed to be clinically significant by our definition: ideal smile arc, ideal buccal corridor, maximum gingival display, upper to lower midline, and cant.

The critical feature of the ideal smile arc is that it parallels the curvature of the lower lip.[7,19,20] Although the

ideal smile arc from our study had a different parabolic curve than the ideal reported by Ker et al,[7] the principle holds true, and it tracked the curvature of the lower lip for both models (Fig 1). The difference in which the curve paralleled the lip most accurately was due to the different lip contour of our models. So, although the numbers were different, this study supports the principle of the ideal smile arc matching the lower lip. This concept and these data supporting the ideal smile arc are well established in the literaturew and agree with these findings.[5-7,19-21] There were no differences for the range of acceptability for this variable.

All 3 buccal corridor measures were statistically different from those of Ker et al[7]; however, only the ideal had reasonable reliability. The 4% buccal corridor difference compared with that of Ker et al[7] equates to a 2 to 3 mm difference in the combined width of the buccal corridors, depending on the width of the smile. So, the full-face raters favored a smaller buccal corridor than did the lower-face raters (Fig 1). The belief that smaller corridors are favored over larger corridors, as shown by Parekh et al,[5,6] Moore et al,[12] and Martin et al[16] was upheld by this study. It is not reasonable to make judgments about the limits of the buccal corridors from this study because of the reliability.

The upper limit for gingival display was much lower than any previously published study that purported to examine the ranges of acceptability or thresholds.[3,6,7,22] This upper limit for gingival display was more than 4 mm lower than found by Ker et al,[7] even though our ideal and lower limit matched closely. Our raters did not favor any gingival display at the central incisors, whereas the raters of Ker et al allowed 3.7 mm of gingival display. Kokich et al[3,22] found either 4 or 3 mm to be the upper acceptable limit. Even though a large range of options was not provided for this variable because of the height of the oral aperture of our 2 models, the raters did not use the limits of the available range. It is possible that differences in the lip contour of these models contributed to this lack of tolerance for gingival display. These models showed similar gingiva laterally to that of Ker et al but less in the central incisor area. This might indicate that gingival display is not confined to just the central incisor area, but it is more of a global evaluation of the maxillary arch. The ideal of 2 mm of tooth coverage was the same as found by Ker et al and not effectively different than averages reported by Tjan et al[19] and Peck and Peck,[23] and the ideal reported by Hunt et al.[24] The lower limit of 4.5 mm was similar to that of Ker et al.[7]

The allowable discrepancy between the upper and lower midlines was found to be 3.6 mm (Fig 2). This was about 1.6 mm more than the difference of 2 mm found by Ker et al.[7] In this case, the belief that full-face raters would allow more leeway was upheld. The lower midline can be off by approximately half of a mandibular incisor width with no esthetic ramifications. This demonstrates that mandibular incisor extractions, for example, would be well tolerated esthetically by laypersons.

The maximum acceptable cant of the occlusion was 2.75° (Fig 1). Given smile widths from 50 to 70 mm, the vertical measure of the cant could be from 2.4 to 3.4 mm. This is quite similar to what Kokich et al[3] found at 3 mm of allowable cant. The 4° limit for cant of Ker et al[7] translates to 3.5 to 4.9 mm of vertical discrepancy. So the vertical difference in millimeters between this study and that of Ker et al ranges from 1.1 to 1.5 mm depending on the width of the smile. This result seems counterintuitive, since we expected the raters to allow more leeway when viewing full faces. It is possible that seeing the whole face made the raters more sensitive to the horizontal axis of the image and to smiles that deviated from it. In either case, laypersons will tolerate quite a bit of canting of the occlusion before rating the image less attractive.

The limit of acceptability for the maxillary midline deviation from the facial midline was found to be 3.2 mm (Fig 1). Although Johnston et al[4] found the limit to be 2 mm, our finding was the same as those of Rodrigues et al[11] and Ker et al.[7] Kokich et al[3] found even more leeway at 4 mm using 1-mm increments. There can be a substantial midline discrepancy before it becomes unattractive.

The ideal overbite was found to be 2.3 mm or 31%, with a minimum of 0.9 mm (12%) and a maximum of 5.4 mm (74%) (Fig 2). This closely matches the findings of Ker et al.[7] The minimum was statistically different from the 0.4 mm of Ker et al but was not clinically significant. Although orthodontists usually level the curve of Spee for practical, mechanical reasons to enable retraction and space closure, leaving more overbite than the 2 mm ideal (27%) is well accepted by laypersons, and there is a great range. More overbite is preferable esthetically than limited overbite or an open bite.

The 2.1-mm acceptability limit for the gingival discrepancy between the central incisors was the same as both Kokich et al[22] and Ker et al[7] found. Laypersons' tolerance for up to a 2-mm difference is consistent (Fig 2).

The ideal central to lateral gingival margin discrepancy of −0.4 mm (ie, the lateral incisor gingival margin was incisal to the central incisor gingival margin) was the same as the −0.4 mm of Ker et al.[7] In the study of Kokich et al,[3] laypersons did not detect differences in any version of this variable, which varied from 1 to 3 mm incisal to the canine gingival margin. The

acceptability limits were statistically different from those of Ker et al but, at less than 1 mm, cannot be considered clinically significant. This provided substantial latitude from −1.9 to 0.4 mm as the acceptable range. This leeway works well with lateral incisal steps; for example, intruding the lateral incisors to increase the lateral step and provide an ideal smile arc would be well tolerated esthetically at the gingival level.

The ideal incisal edge discrepancy or step between the lateral and central incisors was 1.2 mm, and the upper limit was 2 mm (Fig 2). The lower limit was not reported here because Ker et al[7] did not look for a lower limit. Again, these numbers were statistically different from those of Ker et al but not clinically significant. These values are in line with those of Bukhary et al[25] and King et al.[26] Although orthodontists typically set the lateral incisor brackets 0.5 mm incisally to the central incisors, the laypersons' preference for a bigger lateral step was clear. This variability works well with the central to lateral gingival height variation to create an esthetic smile.

These details of the variables indicate several concepts. It appears that all variables but 1 (upper to lower midline) with statistical and clinical significance did so in the context of the face. That is, they required the face as a background to make the judgments as opposed to more of a dental context (upper to lower midlines). In most cases, the raters allowed less range of acceptability (maximum gingival display and occlusal cant) or a smaller ideal (buccal corridor). Certainly, all aspects of these variables did not show this effect.

In most cases, the perspective had little clinical significance. The range of acceptability remained large for most variables, and several variables worked together to produce an esthetic smile with a smile arc coincident with the lower lip. A slightly increased overbite, a central to lateral incisal step, and the central to lateral gingival step can all partner to produce an ideal smile. It should be possible for most practitioners to work in the latitude described by these variables and with sensible occlusal concepts to produce an acceptable and attractive smile.

CONCLUSIONS

1. The acceptable range is quite large for most smile characteristics.
2. The perspective (full face vs lower face) made little difference in the ratings of esthetic variables for the smile.
3. When we found a clinically significant difference, it appeared to have the face as the context.
4. Reliability was fair to moderate for all measures except buccal corridor limits, which had poor reliability.
5. Raters' sex was not critical in the evaluation of smile esthetics.
6. Many esthetic variables complement each other, so that achieving an esthetic smile is clinically possible.

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