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Esthetics and smile characteristics from the layperson's perspective

A computer-based survey study

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The contemporary practice of dentistry must include management of the dentition and soft tissues to create an esthetic smile by means of tooth movement, soft-tissue modification, restorative procedures or some combination of these techniques. The development of an esthetic smile should be based on as much objective evidence as possible. Until recently, however, the refereed literature had not clarified the importance of smile characteristics.[1-9] Investigators conducting studies in restorative dentistry and orthodontics historically have identified esthetic issues[1,4,6-37] and demonstrated that dental professionals and laypeople can identify smile characteristics that both enhance and detract from a smile.

Researchers in some studies have applied computer-based methods to alter dental morphology,[2,18,26,27,31] and this computerized alteration appears to be an effective method of exploring esthetics owing to its consistency of variable manipulation and controlled presentation. Kokich and colleagues,[2] to our knowledge, were the first to use computer-based image modification in

ABSTRACT

Background. The paradigm shift from occlusion to esthetics places more emphasis on the subtle relationships among the teeth and the interplay with the soft tissues. The authors of this study quantified the ideal and maximum acceptable deviations for smile characteristics.

Methods. The authors created a survey by using a digital image editing software package, which enabled raters to manipulate intraoral photographs featured in the survey. They altered smile characteristics in photos of a sex-neutral face showing nasal tip to mentolabial fold. The authors administered an electronic survey in Boston (n = 78); Columbus, Ohio (n = 81); and Seattle (n = 84). An interactive interface allowed raters to select the ideal for each smile characteristic presented and identify the range of acceptability for the variables.

Results. Raters were reliable (κ = 0.34-0.88). Survey location was not significant except that raters from the West accepted a broader smile than did those from the Midwest and the East. Raters identified ideals and thresholds for the following smile characteristics: smile arc; buccal corridor; gingival display; canine and posterior crown torque, ideal and large corridor; maxillary midline to face; maxillary to mandibular midline; overbite; maxillary central incisor gingival height discrepancy; maxillary lateral incisor gingival height discrepancy; maxillary central to lateral incisal step; maxillary central incisor crown width-to-height ratio; maxillary central-to-lateral incisal ratio; and occlusal cant. Generally, the values for ideal paralleled existing data, and new guidelines for some variables emerged. The ranges of acceptability were large.

Conclusions. The ideal and an acceptable range for each smile characteristic can be identified reliably.

Practice implications. Laypeople can reliably identify ideal smile characteristics. The ranges of acceptable deviations for smile characteristics are large, and practitioners should avoid unnecessarily sensitizing patients to minor discrepancies.

Key Words. Smile esthetics; smile arc; buccal corridor; attractiveness; tooth proportion; gingival display; orthodontics; dental esthetics.

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attempting to quantify smile characteristic acceptability by using images of female lips and teeth. They found that orthodontists, general dentists and laypeople were able to detect discrepancies in smile characteristics at differing levels and that, for many variables, laypeople were less discriminating than were practitioners.

However, excessive cropping, skin tone differences, lipstick application and tooth shape can affect the perception of smile characteristics. Other authors[6,9] have advocated the inclusion of more facial features, such as a full-face view, to demonstrate the interaction between all smile-related tissues. Furthermore, presentation of large incremental differences between images (for example, differences of 1 millimeter or more) may have obscured the true threshold of acceptability. It may be possible to refine, confirm and expand the results of previous studies using more advanced digital imaging methods and survey techniques.

A number of variables have been suggested to influence the attractiveness of a smile. Rosenstiel and colleagues[26,27] suggested that the ideal width-to-height ratio for the maxillary anterior teeth is between 70 and 80 percent. The ideal smile arc should mimic the curvature of the lower lip from central incisor to canine.[1,30] Buccal corridor minimization is a critical smile feature.[1,6,8,12,25] Increased torque in posterior teeth is a way to improve the esthetics of narrow smiles.[37,38] Excessive gingival display does not appear to be well-tolerated by raters.[2] The highly variable permanent maxillary lateral incisor can be a challenging tooth to manage orthodontically and restoratively.[39] Maxillary midline deviations can upset the balance of an otherwise esthetic smile.[40-42] A maxillary-to-mandibular midline discrepancy alters anterior esthetics and indicates how posterior teeth will occlude.[43] Overbite generally is characterized as ideal when its value is between zero and 2 mm.[43] The vertical position of the lateral incisor affects the continuity of the smile arc.[44] Kokich and colleagues[2] found an occlusal plane cant to be an overwhelmingly displeasing smile characteristic to health professionals and laypeople. The location, shape and contour of the gingiva in the maxillary anterior region affect smile esthetics.[29] Clearly, there are numerous characteristics that make up a smile, but these must be disaggregated and systematically evaluated to determine their effect.

Bearing these considerations in mind, we undertook a study to identify definitively the ideal and acceptable range of several smile characteristics through presentation of a standardized sex-ambiguous circumoral view including the lower face (a context that provided facial cues to symmetry) using raters from three regions of the United States. Most importantly, the raters were able to manipulate smile characteristics on a visually continuous scale so they could appreciate the realm of possibilities before they chose what they found most appealing or at the threshold of acceptability.

MATERIALS, METHODS AND SUBJECTS

This study and its procedures were approved by the institutional review board of The Ohio State University, Columbus.

Model selection and image manipulation. We examined the digital archive of the The Ohio State University College of Dentistry's Division of Orthodontics for initial images following the protocol described by Parekh and colleagues.[1] We used Adobe Photoshop CS2 (Adobe Systems, San Jose, Calif.) to crop the facial images to show only the lips, nasal tip and mentolabial fold to reduce distractions. To create a "hollow" lip set, we erased the teeth and periodontium from the lower face. We used a single intraoral frontal photograph of an ideally treated dentition for all smile-characteristic manipulation and inserted it inside the lip set after alteration. While conducting the survey, we projected these facial images on the computer screen at a size comparable to that of a face at typical conversational distance and standardized the resolution at 1,024 × 768 pixels.

Survey. We designed the survey to encompass a range of values for many smile characteristics. To make the raters' time requirement reasonable, we constructed two surveys; the same raters did not answer both surveys.

We used FormArtist Professional (Quask, Campbell, Calif.), a survey administration software allowing questions to be linked to images in both surveys. We used the images in this study to display continuously modifiable smiles across a predefined physiological range (Figure A, available as supplemental data to the online version of this article [found at "http://jada.ada.org"]). The changes made during the initial image manipulation in Photoshop produced a visually continuous scale of possible choices when the slider bar coupled with the image was manipulated (Figure B, available as supplemental data to the online ver-

sion of this article [found at "http://jada.ada.org"]).

The study was provided to 300 participants older than 18 years who did not work in the dental profession. We used voluntary-response questions to gather demographic data, including sex, ethnicity and sociodemographic status. Any previous professional dental affiliation disqualified respondents from participation. Raters evaluated 28 (survey 1) or 26 (survey 2) image-based questions. Each question was presented randomly with one of two statements:

- "Please move the slider to select the image you find to be most ideal";
- "Please move the slider to select the first image that you find unattractive."

Raters completed the surveys in Boston; Columbus, Ohio; and Seattle. They used identically configured laptop computers, and all responses were anonymous.

Survey 1 content. Below, we describe the image manipulation for all Survey 1 variables. Table 1 presents a summary of the range of possible values and how each variable was measured.

- Smile arc: We used the method described by Parekh and colleagues[1] to create a series of template parabolas and then used Math GV Version 3.1 (freeware; Greg VanMullem, Bakersfield, Calif.) to generate a nearly continuous set of possible smile arcs.
- Buccal corridor: We manipulated buccal corridor spaces, altering the amount of black space between the lip commissure and the most buccal tooth in the smile by moving the posterior teeth medially or laterally.
- Gingival display: We approached gingival display by modifying the skeletal position of the dental arches in 0.1825-mm increments.
- Canine and posterior crown torque: We "torqued" individual tooth cutouts of the canine or all posterior teeth (first premolar through second molar) positively or negatively through their center of rotation in a smile with an ideal (2 percent bilaterally[25]) or wide buccal corridor. We chose this method because the visibility of the posterior teeth may be different in broad and narrow smiles.

Survey 2 content. For all Survey 2 variables, Table 1 presents a summary of the image manipulation, as well as the range of possible values and how each variable was measured.

- Maxillary midline to face: We defined the ideal maxillary midline for the model and moved the maxillary dentition to the left in 0.1825-mm increments while morphing the posterior dentition to maintain even buccal corridors.
- Maxillary to mandibular midline: With the maxillary dentition static, we moved the mandibular midline to the left in 0.1825-mm increments while maintaining normal posterior overjet.
- Overbite: We altered the amount of overlap of the anterior dentition by moving the mandibular anterior dentition vertically in 0.1825-mm increments. We maintained normal posterior tooth contacts.
- Maxillary central incisor gingival height discrepancy: We created asymmetric gingival levels between the maxillary central incisors by moving the gingiva of the maxillary left central incisor incisally in 0.1825-mm increments.
- Maxillary lateral incisor gingival height discrepancy: An overlay gingival layer allowed apical or incisal movement of the gingival zenith of the maxillary lateral incisors in 0.1825-mm increments.
- Maxillary central to lateral incisal step: We moved the lateral incisors in vertical 0.1825-mm increments apically or incisally.
- Maxillary central incisor crown width-to-height ratio: We altered crown width-to-height ratios of the maxillary central, lateral and canine teeth by moving an overlay gingival layer apically in 0.1825-mm increments. We derived the width-to-height ratio by dividing the maxillary central crown width by its corresponding height.
- Maxillary central-to-lateral incisal ratio: We manipulated the widths of the maxillary lateral incisors to be wider or narrower in 0.1825-mm increments by means of digitally dissected tooth cutouts. We positioned the posterior dentition mesially as needed to maintain tooth contacts.
- Occlusal cant: We canted the entire dentition in one-quarter degree increments in a clockwise direction.

Statistical analysis. We assessed raters' reliability for each variable by means of the weighted κ statistic and using statistical software (SAS, Version 3.1, SAS Institute, Cary, N.C.). We analyzed differences in attractiveness ratings by means of descriptive statistics, including median and 95 percent confidence intervals. To investigate for regional differences, we conducted multiple Mann-Whitney-Wilcoxon tests with a Bonferroni-Holm correction. We used the signed rank test to evaluate the possibility that raters

TABLE 1

Summary: measurement of smile variables.

VARIABLE	RANGE OF VALUES	HOW VARIABLE WAS MEASURED
Survey 1		
Smile Arc At maxillary canine At maxillary second molar	 0-4 millimeters 0-10 mm	Vertical distance from a horizontal tangent through the maxillary central incisal edges to the cusp tip of the maxillary canine or second molar
Buccal Corridor (Bilateral Total) Millimetric Percentage	 0-19 mm 0-26%	Horizontal distance from the facial aspect of the most buccal posterior tooth to a vertical line through the commissure of the lips
Gingival Display	– 5.1 mm to + 5.8 mm	Vertical distance from the gingival zenith of the maxillary central incisors to the nadir of the upper lip above these teeth
Canine Torque Broad smile Narrow smile	 – 10 to + 10 degrees – 10 to + 10 degrees	Amount of positive or negative torque in the bilateral maxillary canine teeth rotated through the center of rotation for each tooth Amount of positive or negative torque in the bilateral maxillary canine teeth rotated through the center of rotation for each tooth
Posterior Crown Torque Broad smile Narrow smile	 – 10 to + 10 degrees – 10 to + 10 degrees	Amount of positive or negative torque in the bilateral maxillary posterior teeth (first premolar through second molar) rotated through the center of rotation for each tooth Amount of positive or negative torque in the bilateral maxillary posterior teeth (first premolar through second molar) rotated through the center of rotation for each tooth
Survey 2		
Maxillary Midline to Face	0-4.4 mm	Horizontal distance from the middle of the embrasure between the maxillary central incisors to a line representing the midline of the face as determined by the nadir of the cupid's bow and center of the philtrum of the upper lip
Maxillary to Mandibular Midline	0-2.9 mm	Horizontal distance between the middle of the embrasure of the maxillary central incisors to the middle of the embrasure between the mandibular central incisors
Overbite	0-9.5 mm	Vertical distance from the maxillary central incisal edge to the mandibular central incisal edge
Maxillary Central Incisor Gingival Height Discrepancy	0-2.9 mm	Vertical distance between the apex of the right maxillary central incisor gingival margin and the apex of the left maxillary central incisor gingival margin
Maxillary Lateral Incisor Gingival Height Discrepancy	1.1 mm apical to central incisor to 3.8 mm incisal to central incisor	Vertical distance between the apex of the maxillary central incisor gingival margin and the apex of the maxillary lateral incisor gingival margin
Maxillary Central to Lateral Incisal Step	0-2.9 mm	Vertical distance between the maxillary central incisor edge and the maxillary lateral incisor edge
Maxillary Central Incisor Crown Width-to-Height Ratio	0.61:1 to 1.2:1	Ratio between the width and the height of the maxillary central incisor crown
Maxillary Central-to-Lateral Incisal Ratio	0.53:1 to 0.76:1	Ratio between the width of the maxillary lateral incisor and the width of the maxillary central incisor
Occlusal Cant	0-6 degrees	Amount of rotation in the maxillary and mandibular dentition from the horizontal plane through the middle of the maxillary central incisors

prefer different amounts of crown torque in canines and posterior teeth when the size of the buccal corridor varies. We set the level of significance at $\alpha = .05$ for all analyses.

RESULTS

Raters' demographics. Not all respondents completed the survey; our final total was 243

TABLE 2

Weighted κ values.

SMILE CHARACTERISTIC RATED	κ VALUE	LOWER CONFIDENCE BOUNDARY (95%)	UPPER CONFIDENCE BOUNDARY (95%)
Smile Arc	0.79	0.74	0.83
Buccal Corridor	0.81	0.76	0.85
Gingival Display	0.87	0.84	0.90
Canine Torque			
Broad smile	0.71	0.65	0.78
Narrow smile	0.70	0.64	0.76
Posterior Crown Torque			
Broad smile	0.72	0.67	0.78
Narrow smile	0.74	0.68	0.80
Maxillary Midline to Face	0.71	0.57	0.85
Maxillary to Mandibular Midline	0.56	0.40	0.72
Overbite	0.88	0.83	0.93
Maxillary Central Incisor Gingival Height Discrepancy	0.70	0.55	0.85
Maxillary Lateral Incisor Gingival Height Discrepancy	0.81	0.77	0.86
Maxillary Central to Lateral Incisal Step	0.47	0.34	0.60
Maxillary Central Incisor Crown Width-to-Height Ratio	0.34	0.13	0.55
Maxillary Lateral-to-Central Incisal Ratio	0.73	0.67	0.79
Occlusal Cant	0.76	0.65	0.88

(81 percent), with approximately one-third of the respondents being from each location (Boston; Columbus, Ohio; and Seattle). The final rater group was composed of 66 percent female raters; the median educational level for all raters was a bachelor's degree or higher, and the median annual income was $100,000 to $150,000. Two hundred (82 percent) of the 243 respondents were white, and the other 43 (18 percent) reported they were Asian, African-American, Hispanic or of other ethnicities.

Reliability. Table 2 presents weighted κ statistics.

Regional effects on raters' preferences. We sorted raters' responses according to their region of residence in the United States. Results of multiple Mann-Whitney-Wilcoxon tests comparing West with East, West with Midwest and Midwest with East indicated that the only significant finding was the preference for broader smiles (buccal corridor of 1.75 mm versus 6.00 mm) by raters in the Western group when compared with the Midwestern and Eastern groups ($P = .025$).

Effect of buccal corridor size on torque preference. There was no difference in raters' perception and preference of buccal crown torque in canines only or in posterior teeth related to the size of the buccal corrditors (Table A, available as supplemental data to the online version of this article [found at "http://jada.ada.org"]).

Defining ideal and acceptable smile characteristics. The numeric value and the associated image for each variable selected by the raters as ideal and the threshold of acceptability are reported for each smile characteristic by using medians. These summary statistics and images for the ideal smile characteristics are displayed in Figures 1 through 10 and in Figures C, D, E, F, G and H (available as supplemental data to the online version of this article [found at "http://jada.ada.org"]).

DISCUSSION

The posed smile is repeatable and displays esthetic characteristics not visible during speaking and in repose. This makes the smile, aside from its social and psychological effects, an important facial state for investigation.

In this study, we surveyed laypeople, because they are the primary consumers of orthodontic services, instead of practitioners, who are providers of care. The possibility of regional differences among the East, West and Midwest had not been considered in previous research, to our knowledge and, ultimately, we found that lay raters in different locations were not significantly different in their assessment of individual smile characteristics. The penetration of mass media and popular culture may be responsible for this finding. The one difference, that raters on the West Coast accepted a broader smile, probably is not clinically significant, given the magnitude of the difference.

Median Value		Depiction
Maximum Tolerable Value	8.5 mm at 7s 3.3 mm at 3s	
Ideal Value	7.2 mm at 7s 2.7 mm at 3s	
Minimum Tolerable Value	2.3 mm at 7s 1.2 mm at 3s	

Figure 1. Smile arc. The ideal smile arc was confirmed to be consonant with the lower lip. mm: Millimeters. 3s: Maxillary canines. 7s: Maxillary second molars.

Median Value		Depiction
Maximum Tolerable Value	5.7 mm	
Ideal Value	2.0 mm	
Minimum Tolerable Value	0.4 mm	

Figure 2. Overbite. The raters preferred a deep bite more than a limited overbite. mm: Millimeters.

It still is unclear how laypeople evaluate smile esthetics. There are many potential distracters and interactions among different smile characteristics. Numerous facial or dental characteristics can be distracters that supersede interpretation of smile characteristic deviation.[15] Standardization of image presentation in a realistic context should allow for true assessment of lay raters' preferences across numerous smile characteristics.

The observation that orthodontic treatment flattens the smile arc[13,45] is less troubling given the findings of this study. Lay raters preferred a consonant smile but accepted a smile with minimal curvature as well (Figure 1). Parekh and colleagues[1] found flat smile arcs to be extremely objectionable, but it appears that there are increments flatter than ideal that are acceptable. We found that the addition of more upward curvature beyond what follows the lower lip did not rate well. Clearly, there is a wide and clinically significant difference between the upper and lower thresholds, but, generally, smiles should follow the curvature of the lower lip.

To enable the smile to follow the curvature of the lower lip, clinicians customarily increase the overbite. Our findings (Figure 2) suggest that lay raters are tolerant of a deeper bite, which enables the creation of a congruent smile arc. In addition, it is common orthodontic practice to incorporate a modest step between maxillary central and lateral incisors despite the absence of evidence that this is a desirable technique. Our findings (Figure 3) support a lateral step up beyond the recommended value (0.5 mm), which allows establishment of a smile arc without excursive interferences. These three aspects of the smile—smile arc, overbite and lateral step—all can work harmoniously and contribute to a more esthetic smile. However, many raters preferred even incisal edges, emphasizing that individual preference should be assessed during finishing.

Previous reports of ideal buccal corridor size vary from 2 percent[6] to 19 percent.[46] Our ideal buccal corridor size (Figure 4) was 16 percent, and our acceptability range was 8 to 22 percent. It appears that raters prefer the appearance of a buccal corridor approaching the 19 percent preferred by untreated patients in the study by Ritter and colleagues.[46] Facial perspective or inclusion of more than the circumoral area, however, may make a difference.

Buccal corridor ratings indicate that visibility of the buccal segments may have an esthetic effect. Crown torque in the posterior segments may be visible, but claims that increased torque improves the esthetics of a narrow smile[37,38] have not been substantiated. In our study, laypeople tolerated nearly every image presented to them and unexpectedly preferred negative torque in narrow smiles (Figures C, D, E and F, available as supplemental data to the online version of this article [found at "http://jada.ada.org"]). Therefore, torque of canine and posterior teeth probably

Median Value		Depiction
Maximum Tolerable Value	2.9 mm	
Ideal	1.4 mm	

Figure 3. Maxillary central-to-lateral incisal step. The raters preferred a greater step to the 0.5-millimeter step customarily used in orthodontics. mm: Millimeters.

Median Value		Depiction
Maximum Tolerable Value	-3.6 mm	
Ideal Value	2.1 mm	
Minimum Tolerable Value	4.0 mm	

Figure 5. Gingival display. mm: Millimeters.

should be controlled primarily for purposes of functional occlusion.

Gingival display has been investigated extensively.[2,13,17,18,28,46-51] Kokich and colleagues[2] first reported that 4.0 mm of gingival display represented the threshold of acceptability but more recently[18] used smaller increments and found it to be 3.0 mm. Our data (Figure 5) indicate the ideal value for gingival display to be 2.1 mm incisor coverage and the acceptable range essentially ± 4 mm. Vertical lip changes occur with aging[52-56] and may make maintenance of gingival display difficult, but finishing orthodontic treatment within the acceptability range should be possible.

The location, shape and contour of the maxillary anterior gingiva are important smile characteristics,[29] especially in the context of a smile with some amount of gingival display. Crown length

Median Value		Depiction
Maximum Tolerable Value	16.0 mm (22% of smile)	
Ideal Value	11.6 mm (16% of smile)	
Minimum Tolerable Value	5.8 mm (8% of smile)	

Figure 4. Buccal corridor. mm: Millimeters.

Median Value		Depiction
Maximum Tolerable Value	2.0 mm	
Ideal	0 mm	

Figure 6. Maxillary central incisor gingival height discrepancy. mm: Millimeters.

discrepancies are most common when one maxillary central incisor is shorter than the contralateral incisor[16] because of uneven wear of one central incisor combined with active incisor eruption. In recent years, investigators have found that laypeople did not detect asymmetric crown length unless one crown was 1.5 to 2.0 mm shorter than the other.[18,57] Our study results corroborated that 2.0 mm is the limit of acceptability for this variable (Figure 6); however, one-third of the raters did not find the discrepancy unacceptable until the heights had a difference of 4.0 mm.

Kokich and colleagues[2] noted that gingival discrepancies between the maxillary central and lateral incisors were not obvious to laypeople. Our study results confirmed the broad range of acceptability for this variable and demonstrated it was acceptable even when the lateral gingival margin was superior to the central gingival

Median Value		Depiction
Maximum Tolerable Value	1.2 mm	
Ideal Value	–0.4 mm	
Minimum Tolerable Value	–2.9 mm	

Figure 7. Maxillary lateral incisor gingival height discrepancy. This maximum discrepancy corroborated previous data. mm: Millimeters.

margin (Figure 7).

Kokich and colleagues[2] also found that laypeople needed a 2.0-mm deviation of the ideal crown length to classify the central incisors as noticeably less esthetic. In their research, Kokich and colleagues defined the ideal central incisor crown width-to-height ratio at approximately 0.77, and the 2.00-mm deviation resulted in a width-to-height ratio of approximately 0.90. In a study in which they reviewed anatomic crown width-to-length ratios, Magne and colleagues[58] found that unworn central incisors had a ratio of 0.78. Results of other studies have shown similar values.[4,27,59] Our findings confirmed these values (Figure G, available as supplemental data to the online version of this article [found at "http://jada.ada.org"]).

Proportional size of the maxillary lateral incisor is an interesting variable because of the tooth's variability in size. Its most frequent anomaly is a peg shape, in which the tooth's width is grossly decreased in comparison with the height. Kokich and colleagues[2] found that the threshold for acceptability was 4.0 mm narrower than the ideal width of the lateral incisor. At the ideal, the lateral incisor's width was 78 percent of the central incisor's width, whereas at the threshold it was 45 percent. Our findings were similar: 72 percent for the ideal and a threshold value of 53 percent (Figure H, available as supplemental data to the online version of this article [found at "http://jada.ada.org"]). We found that lateral incisors can be as wide as 76 percent of the central incisor before becoming unacceptable.

Median Value		Depiction
Maximum Tolerable Value	2.9 mm	
Ideal	0 mm	

Figure 8. Maxillary midline to face. The raters were more critical of this characteristic than in some previous studies. mm: Millimeters.

The maxillary dental midline often is compared with the facial midline using the center of the philtrum[22,23,28,60] and soft-tissue nasion.[23,28] Some authors[11,14,61,62] have demonstrated that maxillary midline discrepancies of more than 2.0 mm were likely to be noticed by laypeople, whereas others[2,57] found that laypeople could not perceive a 4.0-mm deviation. Our findings established the maximum acceptable value to be 2.9 mm (Figure 8), although one-third of our respondents accepted a deviation of 4.3 mm.

Maxillary and mandibular midlines are nonconcident in three-fourths of the population,[22] and small deviations do not cause any detriment to smile esthetics.[43] The contribution of the mandibular midline to esthetics may be diminished owing to the narrow width and uniform size of mandibular incisors.[63] We found that mandibular midline deviation was acceptable until it exceeded 2.1 mm (Figure 9) and one-third of the respondents accepted the maximal deviation of 2.9 mm. This demonstrates that many respondents found this deviation to be acceptable when more than one-half of the mandibular incisor deviated from the maxillary midline. This finding adequately accommodates patients who have a missing or extracted lower incisor.

Asymmetry, even among esthetically pleasing faces, is a typical finding.[64] An occlusal cant is a form of asymmetry that is apparent when a person smiles but is not perceived on intraoral images or study casts.[28] Kokich and colleagues[2] found that laypeople did not detect this type of asymmetry until it reached 3.0 mm (equivalent to 4 degrees). Results of other studies have showed that deviations in cant are not noticeable unless they exceed 2 degrees,[65] 3 degrees[64] or 4 degrees.[24]

Median Value		Depiction
Maximum Tolerable Value	2.1 mm	
Ideal	0 mm	

Figure 9. Maxillary to mandibular midline. This amount of discrepancy is nearly one-half the width of a lower incisor. mm: Millimeters.

Median Value		Depiction
Maximum Tolerable Value	4 degrees	
Ideal	0 degrees	

Figure 10. Occlusal cant. The cant deemed allowable by this study's raters is consistent with that of previous studies. mm: Millimeters.

We found that our lay raters accepted cants of as much as 4 degrees (Figure 10), but one-third of the respondents accepted cants at the maximum deviation of 6 degrees.

CONCLUSIONS

The method of using computer-based slider technology to allow raters to select images that are both ideal and at the threshold of acceptability provided a means of accurately and reliably identifying the ideal value for many smile characteristics. Some values deviated from previous findings, and others were confirmed and more precisely defined by this method. Because substantial variability is reported in the existing literature on this topic, variability remains the issue, making comparison of results cumbersome. We investigated other smile characteristics—torque preference, overbite, maxillary-to-mandibular-midline deviation, lateral incisal step and lateral gingival margin height—for the first time, to our knowledge. The sum of our findings provides an outline clinicians can use to assemble patient-centered orthodontic, restorative and periodontal treatment in a more comprehensive manner than has been possible to date.

Our most important finding probably is the range of acceptability. Lay raters tolerated a wide range of variability for most characteristics, and clinicians' knowledge of what is ideal does not make it appropriate for them to ignore this range. It probably is sound for the clinician to use care in identifying the ideal for patients when that knowledge could sensitize them to unrealistic or unattainable goals. In their naiveté, they are more accepting than practitioners might expect. Remembering that our values as clinicians should not be imposed except near the margins of acceptability probably is the best course. ■

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1. Parekh SM, Fields HW, Beck M, Rosenstiel S. Attractiveness of variations in the smile arc and buccal corridor space as judged by orthodontists and laymen. Angle Orthod 2006;76(4):557-563.
2. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999; 11(6):311-324.
3. Wong NK, Kassim AA, Foong KW. Analysis of esthetic smiles by using computer vision techniques. Am J Orthod Dentofacial Orthop 2005;128(3):404-411.
4. Wolfart S, Thormann H, Freitag S, Kern M. Assessment of dental appearance following changes in incisor proportions. Eur J Oral Sci 2005;113(2):159-165.
5. Thomas JL, Hayes C, Zawaideh S. The effect of axial midline angulation on dental esthetics. Angle Orthod 2003;73(4):359-364.
6. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. Am J Orthod Dentofacial Orthop 2005; 127(2):208-213; quiz 261.
7. Anderson KM, Behrents RG, McKinney T, Buschang PH. Tooth shape preferences in an esthetic smile. Am J Orthod Dentofacial Orthop 2005;128(4):458-465.
8. Roden-Johnson D, Gallerano R, English J. The effects of buccal corridor spaces and arch form on smile esthetics. Am J Orthod Dentofacial Orthop 2005;127(3):343-350.
9. Isiksal E, Hazar S, Akyalcin S. Smile esthetics: perception and comparison of treated and untreated smiles. Am J Orthod Dentofacial Orthop 2006;129(1):8-16.
10. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod 2002;36(4):221-236.
11. Beyer JW, Lindauer SJ. Evaluation of dental midline position. Semin Orthod 1998;4(3):146-152.
12. Gracco A, Cozzani M, D'Elia L, Manfrini M, Peverada C, Siciliani G. The smile buccal corridors: aesthetic value for dentists and laypersons. Prog Orthod 2006;7(1):56-65.
13. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod 1970;57(2):132-144.
14. Johnston CD, Burden DJ, Stevenson MR. The influence of dental to facial midline discrepancies on dental attractiveness ratings. Eur J Orthod 1999;21(5):517-522.
15. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999;11(6):311-324.
16. Kokich V. Esthetics and anterior tooth position: an orthodontic perspective, part I: crown length. J Esthet Dent 1993;5(1):19-23.
17. Kokich VG. Esthetics and vertical tooth position: orthodontic possibilities. Compend Contin Educ Dent 1997;18(12):1225-1231; quiz 1232.
18. Kokich VO, Kokich VG, Kiyak HA. Perceptions of dental professionals and laypersons to altered dental esthetics: asymmetric and symmetric situations. Am J Orthod Dentofacial Orthop 2006;130(2): 141-151.

19. Levin EI. Dental esthetics and the golden proportion. J Prosthet Dent 1978;40(3):244-252.
20. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod 1993;63(3):183-189; discussion 190.
21. Maple JR, Vig KW, Beck FM, Larsen PE, Shanker S. A comparison of providers' and consumers' perceptions of facial-profile attractiveness. Am J Orthod Dentofacial Orthop 2005;128(6):690-696; quiz 801.
22. Miller EL, Bodden WR Jr, Jamison HC. A study of the relationship of the dental midline to the facial median line. J Prosthet Dent 1979;41(6):657-660.
23. Morley J, Eubank J. Macroesthetic elements of smile design. JADA 2001;132(1):39-45.
24. Padwa BL, Kaiser MO, Kaban LB. Occlusal cant in the frontal plane as a reflection of facial asymmetry. J Oral Maxillofac Surg 1997;55(8):811-816; discussion 817.
25. Ritter DE, Gandini LG, Pinto Ados S, Locks A. Esthetic influence of negative space in the buccal corridor during smiling. Angle Orthod 2006;76(2):198-203.
26. Rosenstiel SF, Rashid RG. Public preferences for anterior tooth variations: a web-based study. J Esthet Restor Dent 2002;14(2):97-106.
27. Rosenstiel SF, Ward DH, Rashid RG. Dentists' preferences of anterior tooth proportion: a web-based study. J Prosthodont 2000;9(3):123-136.
28. Sabri R. The eight components of a balanced smile. J Clin Orthod 2005;39(3):155-167; quiz 154.
29. Sarver DM. Principles of cosmetic dentistry in orthodontics, part 1: shape and proportionality of anterior teeth. Am J Orthod Dentofacial Orthop 2004;126(6):749-753.
30. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop 2001;120(2):98-111.
31. Sarver DM, Ackerman JL. Orthodontics about face: the re-emergence of the esthetic paradigm. Am J Orthod Dentofacial Orthop 2000;
117(5):575-576.
32. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification, part 2: smile analysis and treatment strategies. Am J Orthod Dentofacial Orthop 2003;124(2):116-127.
33. Sarver DM, Yanosky M. Principles of cosmetic dentistry in orthodontics, part 2: soft tissue laser technology and cosmetic gingival contouring. Am J Orthod Dentofacial Orthop 2005;127(1):85-90.
34. Steadman SR. Overbites and overjets. Angle Orthod 1974;44(2):156-161.
35. Yang IH, Nahm DS, Baek SH. Which hard and soft tissue factors relate with the amount of buccal corridor space during smiling? Angle Orthod 2008;78(1):5-11.
36. Zachrisson BU. Esthetic factors involved in anterior tooth display and the smile. J Clin Orthod 1998;32:432-445.
37. Zachrisson BU. Making the premolar extraction smile full and radiant. World J Orthod 2002;3:260-265.
38. Zachrisson BU. Premolar extraction and smile esthetics. Am J Orthod Dentofacial Orthop 2003;124(6):11A-12A.
39. Wheeler RC. The permanent maxillary incisors; the permanent mandibular incisors. In: Wheeler RC, ed. A Textbook of Dental Anatomy and Physiology. 3rd ed. Philadelphia: W.B. Saunders; 1958:130-138.
40. Nanda R, Margolis MJ. Treatment strategies for midline discrepancies. Semin Orthod 1996;2(2):84-89.
41. Lewis PD. The deviated midline. Am J Orthod 1976;70(6):601-616.
42. Arnett GW, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning, part II. Am J Orthod Dentofacial Orthop 1993;103(5):395-411.
43. Proffit WR, Fields HW, Sarver DM. Contemporary Orthodontics. 4th ed. St. Louis: Mosby; 2007.
44. McLaughlin RP, Bennett JC, Trevisi HJ. Systemized Orthodontic Treatment Mechanics. Edinburgh, Scotland: Mosby; 2001:324.
45. Ackerman JL, Ackerman MB, Brensinger CM, Landis JR. A morphometric analysis of the posed smile. Clin Orthod Res 1998;1(1):2-11.
46. Ritter DE, Gandini LG Jr, Pinto Ados S, Ravelli DB, Locks A. Analysis of the smile photograph. World J Orthod 2006;7(3):279-285.
47. Peck S, Peck L, Kataja M. The gingival smile line. Angle Orthod 1992;62(2):91-100; discussion 101-102.
48. Peck S, Peck L, Kataja M. Some vertical lineaments of lip position. Am J Orthod Dentofacial Orthop 1992;101(6):519-524.
49. Rigsbee OH 3rd, Sperry TP, BeGole EA. The influence of facial animation on smile characteristics. Int J Adult Orthodon Orthognath Surg 1988;3(4):233-239.
50. Vig RG, Brundo GC. The kinetics of anterior tooth display. J Prosthet Dent 1978;39(5):502-504.
51. Burstone CJ. Lip posture and its significance in treatment planning. Am J Orthod 1967;53(4):262-284.
52. Love RJ, Murray JM, Mamandras AH. Facial growth in males 16 to 20 years of age. Am J Orthod Dentofacial Orthop 1990;97(3):200-206.
53. Mamandras AH. Linear changes of the maxillary and mandibular lips. Am J Orthod Dentofacial Orthop 1988;94(5):405-410.
54. Vig PS, Cohen AM. Vertical growth of the lips: a serial cephalometric study. Am J Orthod 1979;75(4):405-415.
55. Foley TF, Mamandras AH. Facial growth in females 14 to 20 years of age. Am J Orthod Dentofacial Orthop 1992;101(3):248-254.
56. Levine RA, Garza JR, Wang PT, Hurst CL, Dev VR. Adult facial growth: applications to aesthetic surgery. Aesthetic Plast Surg 2003;27(4):265-268.
57. Pinho S, Ciriaco C, Faber J, Lenza MA. Impact of dental asymmetries on the perception of smile esthetics. Am J Orthod Dentofacial Orthop 2007;132(6):748-753.
58. Magne P, Gallucci GO, Belser UC. Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. J Prosthet Dent 2003;89(5):453-461.
59. Gillen RJ, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont 1994;7(5):410-417.
60. Tjan AH, Miller GD, The JG. Some esthetic factors in a smile. J Prosthet Dent 1984;51(1):24-28.
61. Frush JP, Fisher RD. The dynesthetic interpretation of the dentogenic concept. J Prosthet Dent 1958;8:558-581.
62. Cardash HS, Ormanier Z, Laufer BZ. Observable deviation of the facial and anterior tooth midlines. J Prosthet Dent 2003;89(3):282-285.
63. Zachrisson BU. Esthetics in tooth display and smile design. In: Nanda R, ed. Biomechanics and Esthetic Strategies in Clinical Orthodontics. St. Louis: Elsevier Saunders; 2005:110-130.
64. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod 1995;1(2):105-126.
65. Geron S, Atalia W. Influence of sex on the perception of oral and smile esthetics with different gingival display and incisal plane inclination. Angle Orthod 2005;75(5):778-784.