Original Article

Attractiveness of Variations in the Smile Arc and Buccal Corridor Space as Judged by Orthodontists and Laymen

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ABSTRACT

Objective: To evaluate changes in attractiveness on the basis of computerized variations of smile arcs and buccal corridors for male and female smiles judged by orthodontists and laypersons.

Materials and Methods: Using a visual analog scale in a Web-based survey, orthodontists and laypersons rated the attractiveness of nine digitally altered smile arc and buccal corridor variations of male and female smiles. The variations were accomplished in a clinically relevant manner and based on standards set by experienced orthodontists in a pilot web-based survey.

Results: The results indicate that both laypersons and orthodontists prefer smiles in which the smile arc parallels the lower lip and buccal corridors are minimal. Significantly lower attractiveness ratings were found for smiles with flat smile arcs and excessive buccal corridors. Flattening of the smile arc overwhelms the deleterious effects of excessive buccal corridors on attractiveness ratings.

Conclusions: On the basis of the results of this study, care should be taken not to produce an excessively flat smile arc during orthodontic treatment. (*Angle Orthod* 2006;76:557–563.)

KEY WORDS: Smile esthetics; Attractiveness; Smile arc; Buccal corridor; Visual analog scale

INTRODUCTION

Most orthodontists understand that the attainment of optimal esthetics is complex and involves the relationship of the teeth to both intraoral and extraoral soft tissues. Two aspects of smile esthetics, smile arc and buccal corridor space, recently captured the interest of clinicians despite little scientific evidence.[1]

Sarver[2] recently focused his treatment planning on obtaining the ideal smile arc described by the curvature of the maxillary incisal edges being parallel to the curvature of the lower lip, which is similar to the concept of Frush and Fisher.[3] Hulsey[4] was one of the first to quantify the smile arc, and the results of his study showed that orthodontically treated patients had lower smile ratios (flatter) than untreated patients.

Another concept originally attributed to Frush and Fisher[3] was the presence of buccal corridor spaces, the negative space created between the buccal surfaces of the posterior teeth and the inner wall of the cheek. Hulsey[4] found that buccal corridor spaces did not contribute significantly to smile esthetics.

Studying smile esthetics was difficult because of the inability to standardize a realistic model and alter the variables of interest. Digital imaging allows manipulation of the variables in a reliable and quantifiable manner. Sarver and Ackerman[5] and Kokich et al,[6] using computer simulation, have applied this methodology to smiles.

Roden-Johnson et al,[7] using computer simulations of buccal corridors spaces, validated Hulsey's original findings using smiles with three different arch forms to display absent and large buccal corridor spaces, which were then rated on a visual analog scale (VAS). Orthodontists preferred normal to broad arch forms compared with untreated, narrower arch forms, whereas lay people demonstrated no preference. More significantly, buccal corridor spaces did not have an effect on the smile ratings of orthodontists, general dentists, and lay people.

In contrast, Moore et al[8] recently found that layper-

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sons could differentiate between different percentages of buccal corridor space except when they became minimal. Using full-face color photographs with five alterations in buccal corridor, they preferred faces with minimal buccal corridor spaces significantly more than narrow smiles.

The purpose of this study was to evaluate, using digital manipulated images and an internet study, the effects of changes in smile arcs and buccal corridors and their interactions on the perceptions of smile attractiveness as judged by orthodontists and lay raters.

MATERIALS AND METHODS

Image manipulation

After IRB approval, a digital archive was examined to obtain one frontal intraoral photograph of ideally aligned teeth and one extraoral photograph that displayed esthetic lips from different patients. These images were modified using Adobe Photoshop® 7.0 (San Jose, Calif) to create a bilaterally symmetric set of teeth and a set of lips without evidence of teeth and periodontium. The set of teeth were morphed using a three-dimensional spherical render function to modify the curvature of the incisal edges to fit 12 curves ranging from flat to accentuated based on sequentially increasing parabolic arcs, numbered 1–12, respectively. The lips were modified so that the lower lip would coincide with the number 7 curve.

The number 7 smile arc and lips were combined to form the ideal composite smile with all teeth displayed to the maxillary second molar. By airbrushing, seven different sizes of buccal corridor quantified in relation to the teeth numbered 1–7 were created. These digital methods were used because Sarver[2] notes clinical methods, such as extruding the maxillary anterior teeth, lingual tipping the maxillary incisors, clockwise rotating of the palatal or occlusal planes (or both), and maxillary posterior impaction surgery, are used to change the smile arc. The digital manipulation of the dentition was accomplished in exactly the same manner to increase the smile arc within the soft tissue as proposed clinically.

To create a ''male'' set of lips, an overlay was used to create typical facial hair. A composite smile could then be completed by combining a set of teeth and lips with buccal corridor and facial hair as needed.

Pilot survey

Pilot surveys were administered to experienced orthodontists (at least 5 years postresidency) to set the standards for the ideal smile arc, the maximum acceptable accentuated smile arc, the ideal buccal corridor (ie, the ideal amount of black space), and an excessive buccal corridor (ie, too much black space). Forty orthodontists who were randomly chosen from those listed in the American Association of Orthodontists Directory participated in the pilot survey. The survey asked the rater for the year of completion of residency and an e-mail address so that a follow-up reliability survey could be completed at least 2 weeks later. Orthodontists completing the pilot survey were on average 23 years postresidency.

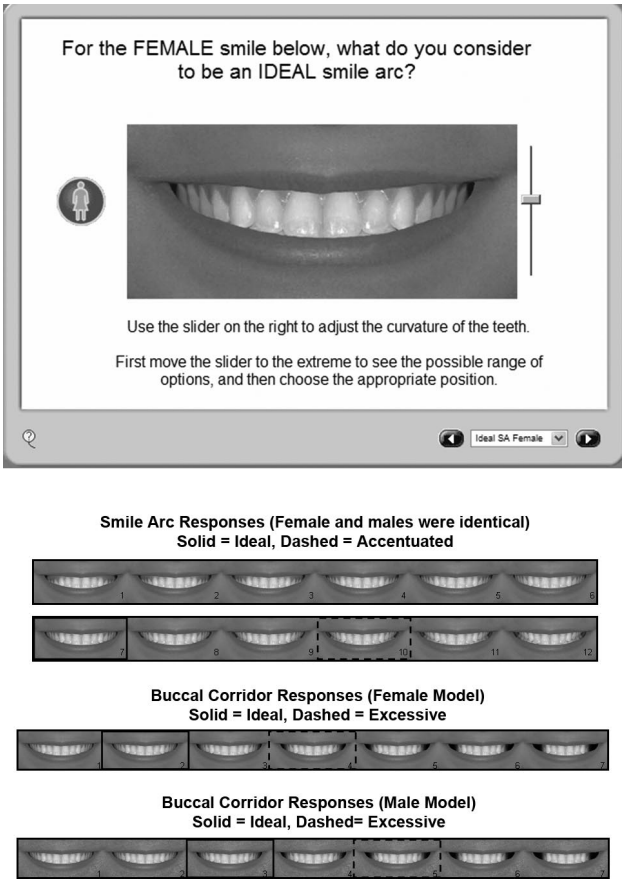


FIGURE 1. Illustrates an example of an emoticon, displayed images, and results from the pilot survey.

The orthodontists were given written definitions of smile arcs and buccal corridors and asked to use the slider to set the visual standards for smile arc and buccal corridor variations for male and female smiles. Figure 1 illustrates an example question, available choices, and responses from the pilot survey.

Quask™ Form Artist (New Canaan, Conn) was used to author the web survey and allowed the creation of emoticons, which are interactive sliding bars that display a changing picture when the slider is activated. One emoticon displayed smile arcs, whereas another displayed buccal corridors.

Main survey

For the main survey, 115 available laypersons and 131 orthodontists responded and voluntarily provided

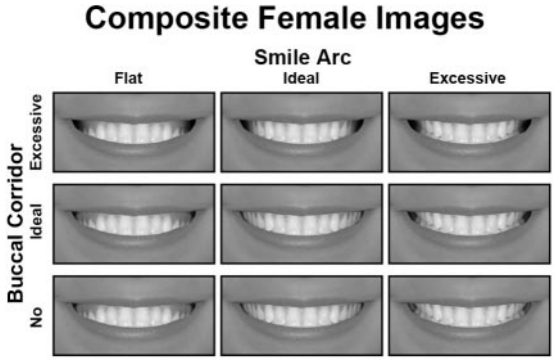


FIGURE 2. Illustrates the nine final composite female images presented in the main survey with alterations in smile arc and buccal corridor.

demographic information including sex, US geographical region, ethnic background, highest level of education completed, and any dental affiliation. Orthodontists were asked for the year they completed their professional training. Laypersons were asked to choose their income bracket.

The majority of orthodontists were male, Caucasian, from the central United States, and 22 years postresidency. They were not included in the pilot survey. Available laypersons were contacted with conscious effort not to include those with dental affiliations. The majority of laypeople were college educated, Caucasian, and from the central United States with a median income of $50,000 to $75,000.

Median values from the pilot survey were used to create images for the main study. Flat smile arcs and absent buccal corridors were considered to be inherently defined. The number 11 smile arc established the excessive smile arc because this was beyond the maximum acceptable level initially set by the orthodontists. Combinations of the three smile arc variations (flat, ideal, excessive) and the buccal corridor variations (none, ideal, excessive) were used to create nine female and nine male images. Figure 2 illustrates the nine composite female smiles.

The main survey was created using Quask™ Form Artist. The raters rated each image on a VAS anchored with highly unattractive on the left and highly attractive on the right. Visual cues were also included. Because resolution settings and computer monitor sizes affect the size of the VAS, and they varied among raters, the rating was based on a percentage of the line length in pixels, which standardized the responses regardless of the monitor used.

Raters were asked to evaluate the nine female and nine male smiles twice to determine reliability for a total of 36 smiles, which were randomized each time the survey was taken.

Statistical analysis

Reliability of the ratings for the pilot surveys and the attractiveness portion of the main survey were tested using the intraclass correlation coefficient (ICC) with a 95% confidence interval. The mean scores from both attractiveness ratings were adjusted using the least means squared method. Differences in attractiveness ratings were analyzed using a factorial analysis of variance (ANOVA) with repeated measures. Post hoc testing was done using the Tukey-Kramer method. The level of significance was set at $P < .05$.

For an alpha level of 0.05 and assuming a common standard deviation of 17.42,[9] a sample size of 90 per rater group was necessary to achieve a power of 0.85 to demonstrate a difference of $\pm$10% on the VAS.

Limited data exist to define a clinically significant difference on a VAS for dental attractiveness. The VAS has been validated for pain research and generally a minimum clinically significant difference ranges from 9 to 13 mm on a 100-mm VAS.[10–14] Although it is not known whether this difference translates to attractiveness, this study set a conservative and arbitrary benchmark of a 15% VAS difference as clinically significant.

RESULTS

Reliability

For the pilot surveys, the overall ICC (with 95% confidence interval) was 0.94(0.91–0.95). For attractiveness, the overall ICC for rating the same picture twice in the main study was 0.87(0.83–0.91) with laypersons and orthodontists showing reliability of 0.91(0.89–0.93) and of 0.81(0.77–0.85), respectively. This is a high level of reliability in making judgments on the smiles.

Attractiveness

The results of ANOVA demonstrated that all significant effects were addressed through the following two interactions: Model Gender by Buccal Corridor by Smile Arc and Rater Gender by Group by Buccal Corridor by Smile Arc. Figure 3 illustrates the attractiveness of all the ratings depending on the sex of the model for buccal corridor and smile arc variations. Attractiveness scores for all smile arcs with absent and ideal buccal corridors were nearly identical for males and females, whereas excessive buccal corridors brought all ratings down. For both sexes, flat smile arcs overwhelmed the attractiveness of all buccal corridors and were rated in the lower 40% of the scale.

Regardless of sex, for all buccal corridors, the raters significantly preferred the ideal and excessive smile arcs compared with the flat smile arcs. Buccal corridor

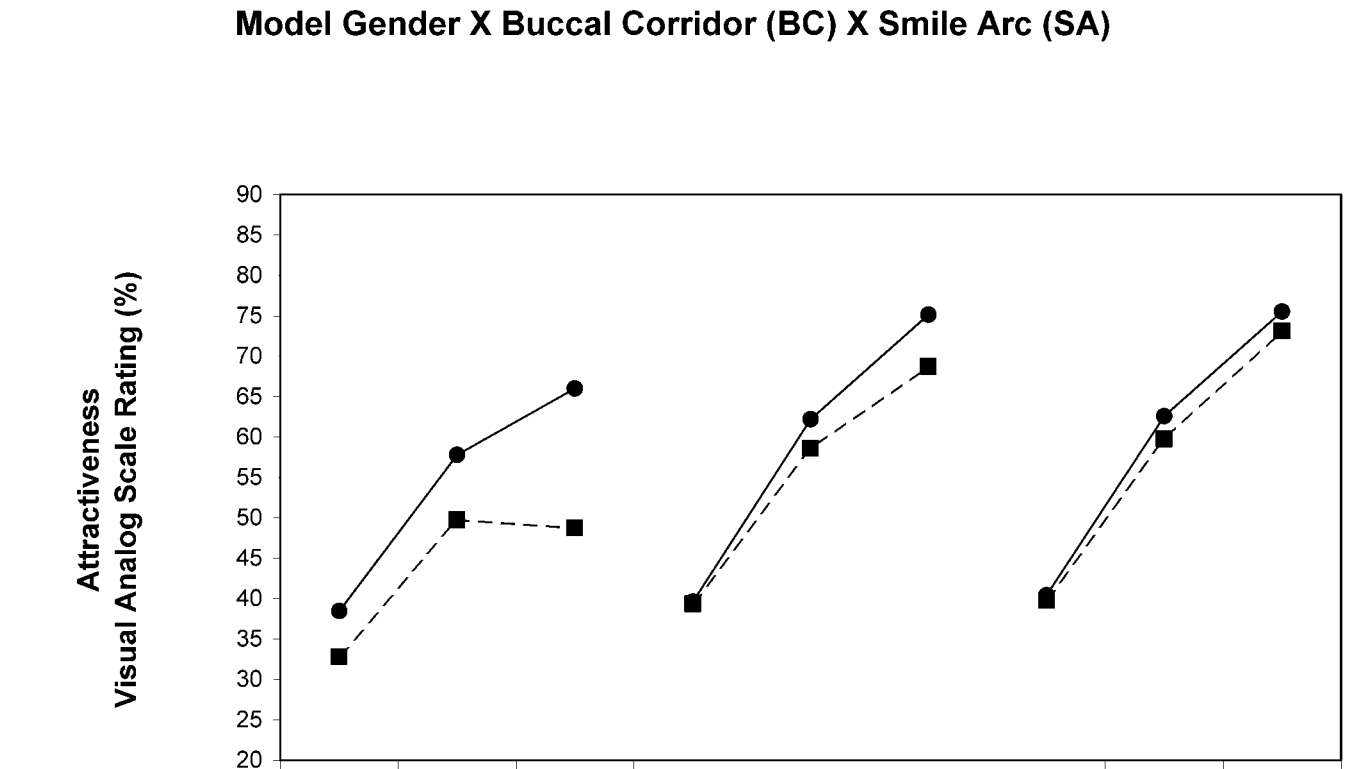


FIGURE 3. Represents the interactions between model gender, buccal corridor, and smile arc. A difference of 15% or greater between variables was considered a clinically significant difference.

size made a significant difference only when the smile arc was ideal for males. For females, all buccal corridor widths with ideal and excessive smile arcs were found to be in the upper half of the attractiveness scale. This was true for males except when the buccal corridors became excessive.

Figure 4 illustrates the attractiveness ratings of male and female laypersons and orthodontists for buccal corridor and smile arc variations. Orthodontists, especially female orthodontists, used a greater range of the rating instrument than laypersons. Buccal corridors and smile arcs generally made less difference to laypersons than to orthodontists. All raters, regardless of buccal corridors, generally preferred ideal smile arcs compared with excessive smile arcs and excessive smile arcs compared with flat smile arcs.

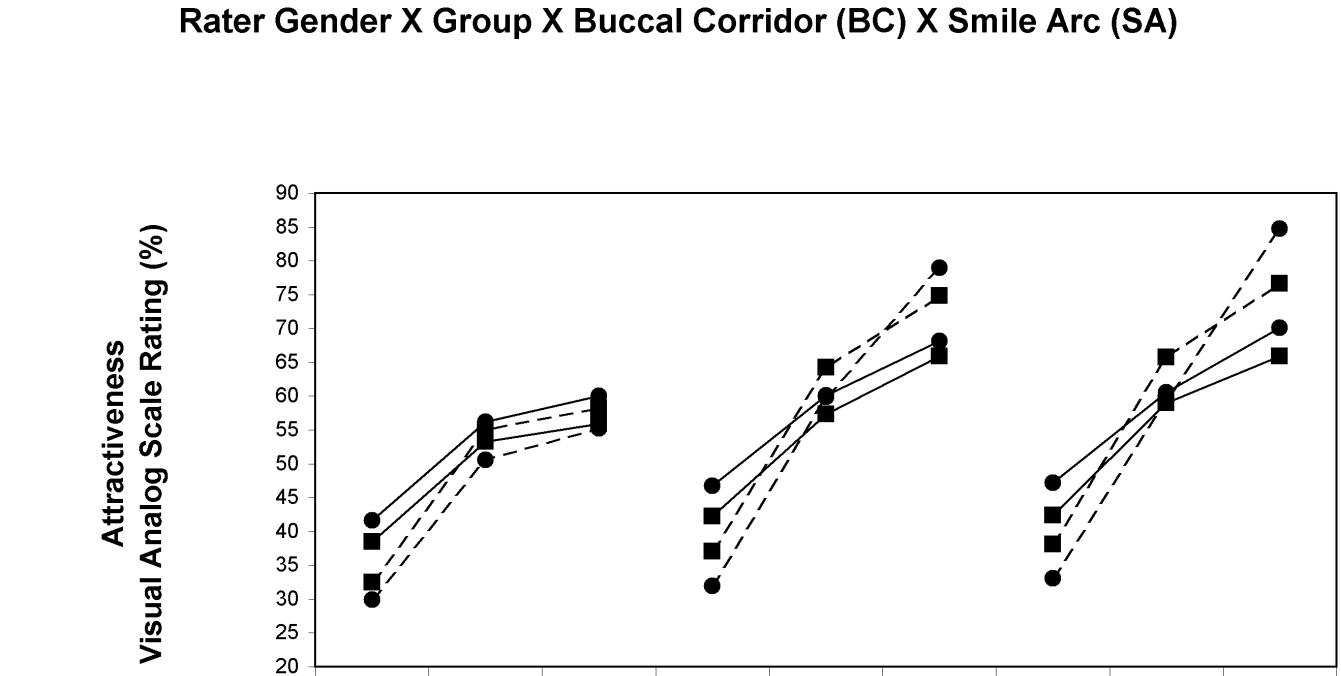
Specific findings included all raters regardless of buccal corridor rated ideal smile arcs significantly more attractive than flat smile arcs. All orthodontists, regardless of buccal corridors, rated the excessive smile arc as significantly more attractive than the flat smile arc. With all buccal corridors, the orthodontists rated the flat smile arc lower than the laypersons. There were no significant differences between male and female laypersons or orthodontists for any ratings.

DISCUSSION

Data collection methods

The results of the pilot study indicated that this was a highly reliable method for studying smile esthetics. An ICC of 0.94 with a 2-week period between ratings was an excellent result. Recently, the VAS gained popularity for measuring subtle differences in dental and facial attractiveness.[6,7,9,15–21] In evaluating dental attractiveness, moderately high correlation coefficients for reliability (0.87) have been reported with the use of the VAS.[22]

The VAS allowed a simple and rapid method for raters to judge attractiveness using a continuous scale and did not restrict raters to categories. But, the scale may mean different things to different raters, all responses may not be equal,[23] and raters will use different portions of the scale and ignore others—particularly the extremes.[18] To address these limitations, this



	Flat SA Excessive BC	Excessive SA Excessive BC	Ideal SA Excessive BC	Flat SA Ideal BC	Excessive SA Ideal BC	Ideal SA Ideal BC	Flat SA No BC	Excessive SA Flat SA	Ideal SA No BC
Female Laypersons (n=55)	41.7	56.2	60.1	46.8	60.1	68.1	47.2	60.6	70.1
Male Laypersons (n=60)	38.5	53.3	55.9	42.2	57.3	65.9	42.4	59.0	65.9
Female Orthodontists (n=15)	29.9	50.6	55.2	31.9	59.9	79.0	33.1	59.4	84.7
Male Orthodontists (n=116)	32.5	55.0	58.2	37.1	64.3	74.8	38.1	65.8	76.7

FIGURE 4. Represents the interactions between rater gender, group, buccal corridor, and smile arc. A difference of 15% or greater between was considered a clinically significant difference.

study used an adjusted mean to compare ratings across groups.

A Web-based survey introduced a potential bias because it was limited to raters with Internet computer access. The lay population appears to have a slightly higher socioeconomic status than the general population (household income of $43,318[24]). These biases should be considered when generalizing the results.

Attractiveness

This study examined attractiveness depending on the smile arc and the buccal corridor because there were possible interactions. The sex of the model only demonstrated importance when the smile arc was ideal and the buccal corridor excessive (Figure 3). Under these conditions, the male was viewed as more unattractive, perhaps because the excessive buccal corridor set by the pilot study was much larger than that for the females.

Although female orthodontists used more of the rating scale than others, and they detected significant differences between some categories male orthodontists did not, there were no significant differences between sexes for either orthodontists or laypersons (Figure 4). Although no other studies have reported differences between male and female orthodontists, some studies have shown that females tend to rate attractiveness higher than their male counterparts[25,26] and laypersons have been reported to be less critical than orthodontists[27] when rating profiles.

Comparison to previous research

As mentioned previously, Hulsey[4] found ideal smile arcs had higher smile scores and buccal corridors did not affect smile scores. The findings of this study agree with those of Hulsey's study regarding smile arc and partially agree regarding buccal corridors. A flat smile arc will significantly reduce the attractiveness of any male or female smile regardless of the buccal corridor size. The raters in this study found no differences in buccal corridor except when they became excessively large and the smile arc was ideal. It is possible that Hulsey's buccal corridors were not large enough to elicit a negative response.

Yoon et al[28] performed a similar study in Korea and found higher esthetic scores for ideal smile arcs as

well as for smiles displaying a greater number of teeth. This is in agreement with this study.

Two recent studies examined the effect of buccal corridor on smile esthetics using digital manipulation. Roden-Johnson et al[7] found no difference in female smiles with and without buccal corridors when judged by orthodontists, general dentists, and laypersons. This contrasts the results of this study for buccal corridors, where orthodontists detected some differences and laypersons did not. Roden-Johnson et al did not quantify buccal corridors—they were classified as present or absent. It is possible that their buccal corridors did not meet the threshold for excessive buccal corridors determined by this study.

Moore et al[8] found that laypersons were able to distinguish differing levels of buccal corridor and preferred broader smiles with minimal buccal corridors. That study quantified buccal corridors as a percentage of total smile width and found no significant differences between medium-broad and broad buccal corridors. This study agrees with Moore et al[8] for analogous (based on percentage translation) minimal buccal corridors judged by laypersons, but they examined a greater range of corridor sizes. This study found differences for male models when the smile arc was ideal. There were no differences for model gender in Moore et al.[8]

There were no differences for sex of lay raters in the study of Moore et al[8] or in this study. We also did not find differences between attractiveness ratings for male and female orthodontists, but female orthodontist did detect some differences not seen by male orthodontists.

The methods of Moore et al[8] were distinctly different from those in this study. They used comparisons of one image to another, whereas this study attempted to judge innate attractiveness on an anchored scale.

The clinician should avoid flat smile arcs and excessively wide buccal corridors with ideal smile arcs to achieve esthetic smiles. These goals can be achieved by carefully planning treatment and by attending to arch form, the inclination of the occlusal plane, and anterior vertical tooth position, especially during finishing.

CONCLUSIONS

- Excessive buccal corridors and flat smile arcs in both male and female smiles are rated as less attractive by both orthodontists and laypersons.
- Flat smile arcs overwhelmingly decrease attractiveness ratings regardless of the buccal corridor.

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