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The impact of buccal corridors on smile attractiveness

Adam J. Martin, Peter H. Buschang, Jimmy C. Boley, Reginald W. Taylor and Thomas W. McKinney
Department of Orthodontics, Baylor College of Dentistry, Texas A&M Health Sciences Center, Dallas, Texas

SUMMARY The aim of this study was to assess the impact of various sized buccal corridors (BCs) on smile attractiveness. One female smiling photograph, displaying first molar to first molar (M1–M1), was digitally altered to produce (1) smiles that filled 84, 88, 92, 96, and 100 per cent of the oral aperture; (2) second premolar to second premolar smiles (PM2–PM2) that filled 84, 88, 92, and 96 per cent of the oral aperture; and (3) smiles with asymmetrical BC that filled 88, 90, 94, and 96 per cent of the oral aperture. The 18 smiles produced were evaluated by 82 orthodontists (70 males and 12 females) and 94 laypeople (40 males and 54 females). Paired *t*-tests were used to evaluate differences within the orthodontist and laypeople groups: independent *t*-tests were used to compare the two groups. The effect of age and gender on the ratings was evaluated by two-way analysis of variance.

Orthodontists and laypeople rated smiles with small BCs as significantly ($P < 0.05$) more attractive than those with large BCs. Orthodontists rated M1–M1 smiles as more attractive than PM2–PM2 smiles, whereas laypeople preferred PM2–PM2 smiles. Orthodontists rated only two of eight asymmetrical smiles as less attractive than would be expected for symmetrical smiles with similar arch widths; laypeople did not rate any asymmetrical smiles as less attractive than would be expected. Rater age and gender did not significantly influence the impact of BCs on smile attractiveness.

Introduction

Physical attractiveness plays an important role in how we view ourselves and how we are viewed by others (Dion *et al.*, 1972; Clifford, 1975; Cash *et al.*, 1977). Dentofacial attractiveness is a major determinant of overall physical attractiveness (Linn, 1966; Shaw *et al.*, 1985; Jenny *et al.*, 1990). Individuals mainly focus on other people's eyes and mouths during interpersonal interaction, with little time spent on other facial features (Miller, 1970). In the mind of the general public, the smile ranks second only to the eyes as the most important feature in facial attractiveness (Goldstein, 1969).

Smile attractiveness includes a number of important components. First, the smile arc should follow the path defined by the edges of the maxillary central incisors, lateral incisors, and tips of the canines (Frush, 1958); it should be consonant with the curvature of the lower lip (Hulsey, 1970; Sarver, 2001). The gingival margins of the central incisors should be positioned apical to those of the lateral incisors and at the same level as the canines (Kokich, 1996). There should be approximately 1.0 and −1.0 mm of gingival display for females and males, respectively (Tjan *et al.*, 1984; Peck and Peck, 1995). Whiter teeth are aesthetically pleasing to patients, regardless of whether or not dentists agree (Alkhatib *et al.*, 2004; Shulman *et al.*, 2004). The golden proportion, while a useful guide for tooth size relationships (Levin, 1978; Ricketts, 1982), does not seem to hold for the majority of natural dentitions (Preston, 1993). Females tend to prefer smiles with round and square-round teeth, while males prefer smiles with square teeth (Anderson *et al.*, 2005).

One of the more controversial aspects of smile attractiveness pertains to buccal corridor (BC) size, defined variably as the space between the buccal surfaces of the maxillary teeth and the corners of the mouth during a smile. Assuming that small BCs make a smile more attractive (Dierkes, 1987; Blitz, 1997; Morley and Eubank, 2001; Sarver, 2001; Sarver and Ackerman, 2003), orthodontic expansion has been proposed to improve smile attractiveness (Sarver, 2001; Sarver and Ackerman, 2003). Importantly, Moore *et al.* (2005) provide the only data demonstrating that broader smiles with no BCs are more attractive than smiles with BCs. Studies indicating that BCs do not impact on smile attractiveness have used inter-canine width to define BC size (Hulsey, 1970; Roden-Johnson *et al.*, 2005) or have not adequately controlled for individual differences in BC size (Johnson and Smith, 1995; Kim and Gianelly, 2003).

In order to provide clinical guidelines, it is important to determine whether orthodontists and laypeople perceive BCs differently. Most studies have only evaluated laypeople's perceptions of BCs (Hulsey, 1970; Johnson and Smith, 1995; Kim and Gianelly, 2003; Moore *et al.*, 2005). Roden-Johnson *et al.* (2005) found no differences between orthodontists and laypeople in their perceptions of attractiveness, but their definition of BC size was based on inter-canine width. Because orthodontists often expand arches, it is also important to know if and how changes in the number of teeth displayed affects BC attractiveness (Sarver and Ackerman, 2003). The effects of BC asymmetry must also be better understood. Hulsey (1970), for example, found a significant positive relationship between symmetry

and attractiveness ratings of smiles. When faces are digitally altered to increase symmetry, they appear more attractive than the originals (Rhodes *et al.*, 1998; Perrett *et al.*, 1999). However, mild facial asymmetry is imperceptible or actually beneficial to facial attractiveness (Swaddle and Cuthill, 1995; Kowner, 1996; Kokich *et al.*, 1999). Studies also remain controversial as to whether or not females are more perceptive to differences in BC size than males (Brisman, 1980; Dunn *et al.*, 1996; Moore *et al.*, 2005). Finally, the literature indicates that the perception of facial attractiveness is similar across age groups (Cross and Cross, 1971; Cavior and Lombardi, 1973; Kissler and Bauml, 2000), even though age effects on BC size have not been investigated.

Based on the aforementioned controversies and lack of supporting evidence, the objectives of this study were to determine if (1) BCs have an impact on smile attractiveness; (2) there is a difference in the way laypeople and orthodontists perceive BCs; (3) the number of teeth displayed while smiling influences the impact of BCs on smile attractiveness; (4) mild asymmetry influences the impact of BCs on smile attractiveness; and (5) age or gender influence the impact of BCs on smile attractiveness.

Subjects and methods

To limit confounding factors, this study was based on one photograph of a smiling female with no obvious facial or dental defects (Figure 1). The original smile, which displayed all maxillary teeth from first molar to first molar (referred to as a M1–M1 smile), was not used in the survey. It was modified using Adobe Photoshop® (Adobe Systems, San Jose, California, USA) to illustrate the average BC ratios ranging between 1.0 and 0.84 with an average (Johnson and Smith, 1995) of 0.92 (Figure 1). In other words, the original smile was altered so that the teeth occupied 84–100 per cent of the oral aperture. BCs were expressed as a ratio:

$$\frac{\text{visible maxillary dentition width}}{\text{oral aperture width}}$$

The smile was modified in the following ways: (1) the size of the BCs was changed bilaterally by altering the maxillary dental arch width, while holding the number of posterior teeth that were showing constant; (2) the size of the BCs was changed bilaterally by reducing the number of posterior teeth showing and then applying the first method; and (3) the size of the BCs was changed unilaterally to create smiles with asymmetrical BCs. The modified smiles were compiled in a survey that was administered to orthodontists and laypeople for the evaluation of smile attractiveness.

Changing BC size by altering maxillary dental arch width bilaterally

Starting with the M1–M1 0.92 smile, the posterior teeth (first molars, second premolars, and first premolars) and canines were isolated from the rest of the image using the Photoshop's® layer function so they could be modified independently. The teeth were expanded or constricted to simulate changes in maxillary dental arch width. As arch width was increased, the mesial–distal dimensions of the teeth appeared larger. Changes in arch width were used to create a group of M1–M1 smiles with BC ratios that were one and two standard deviations (1 SD = 0.04; Johnson and Smith, 1995) above and below the average 0.92 smile (Figure 1).

Figure 1 Symmetrical M1–M1 smiles of the original image and digitally modified images (buccal corridor ratio on the right).

Changing BC size by reducing the number of posterior teeth

The first molars were digitally removed from the M1–M1 0.92 smile to create a smile displaying second premolars to second premolars (PM2–PM2). The PM2–PM2 smile was then modified to have an average BC ratio of 0.92. The second premolars, first premolars, and canines were expanded or constricted bilaterally to simulate changes in maxillary dental arch width. Changes in arch width on the smile were used to create a group of PM2–PM2 smiles with BC ratios 1 and 2 SDs above and below the average (Figure 2). The PM2–PM2 smile with a BC ratio of 1.00 (2 SD above average) was not used because the canine and posterior teeth appeared unnatural, which was reported by respondents during validation to detract from the attractiveness of the smile.

Asymmetrical BC modification

When expressing the BC ratio for a symmetrical smile, one number is sufficient (e.g. 0.92). Descriptions of asymmetrical smiles require two numbers—one for each BC. For example, an asymmetrical M1–M1 0.94 smile might be described as a M1–M1 0.46/0.48 smile, indicating that the left BC (as it appears on the page) was average and the right BC was smaller (less dark space) than average. The asymmetrical side was varied from left to right in the survey, but for simplicity in reporting the results, left is always written as 0.46 (Figure 3).

Figure 2 Symmetrical PM2–PM2 smiles (buccal corridor ratio on the right).

Figure 3 Asymmetrical M1–M1 smiles (buccal corridor ratio on the right).

Beginning with the average (0.92 = 0.46/0.46) smiles, the photographs were altered unilaterally to create smiles with asymmetrical BCs. One side retained the average value (0.46) and the other side was altered up to 2 SD above and below average (1 SD = 0.02; range of 0.50–0.42). The 0.46 ratio side was used because it was the average value and less likely to overemphasize the asymmetries. The M1–M1 asymmetrical smiles included the following: 0.46/0.50, 0.46/0.48, 0.46/0.44, and 0.46/0.42. The PM2–PM2 asymmetrical smiles included the following: 0.46/0.48, 0.46/0.44, and 0.46/0.42.

Instrument validation and data collection

The survey contained a total of 18 smiles: nine symmetrical smiles, seven asymmetrical smiles, and two repeated smiles (M1–M1 0.84 and M1–M1 0.92) to test reliability. The smiles were randomized and placed four smiles per page, for a total of five pages of smiles. Including the instruction sheet, the survey was six pages long. A visual analogue scale (VAS) was placed to the right of each smile to allow respondents to rate the attractiveness of each smile independently (Figure 4). The anchors for the VAS were 'less attractive' on the left and 'more attractive' on the right. Beneath a set of written instructions, two examples showed respondents how to use the VAS and what to do if they wanted to change one of their responses. All respondents were asked to indicate age group and gender. Orthodontists were asked to confirm that they had graduated from an accredited orthodontic programme.

To validate the survey instrument, the instructions and images were pilot tested on multiple Baylor College of Dentistry faculty and orthodontic residents. Their feedback was used to modify the photographs and instructions. No one indicated that the final survey images appeared digitally altered and all agreed that the instructions were clear.

Table 1 Survey respondents by age and gender.

Age (years)	Orthodontists			Laypeople		
	Male	Female	Both	Male	Female	Both
18–29	1	1	2	10	13	23
30–39	9	4	13	8	14	22
40–49	17	2	19	8	10	18
50+	43	5	48	14	17	31
Total	70	12	82	40	54	94

A total of 94 laypeople and 82 orthodontists completed the survey (Table 1). Surveys were administered by the principle investigator to laypeople in waiting rooms at Baylor College of Dentistry, to people at the airport waiting for flights, and to friends and family (who did not know the purpose of the study). The surveys were also administered to orthodontists at professional meetings and to members of the Baylor College of Dentistry orthodontic faculty.

The attractiveness ratings for each smile were measured using Dentofacial® Planner software (Dentofacial Software, Toronto, Canada) and exported to the Statistical Package for Social Sciences (SPSS Inc., Chicago, Illinois, USA) for analysis.

Statistical analysis

Skewness and kurtosis statistics showed the distributions to be normal. Paired *t*-tests were used to evaluate the difference in attractiveness ratings for smiles within the orthodontist or laypeople groups. Independent *t*-tests were used to compare the difference in attractiveness ratings between orthodontists and laypeople. Two-way analysis of variance evaluated the effects of age and gender on ratings of smile attractiveness.

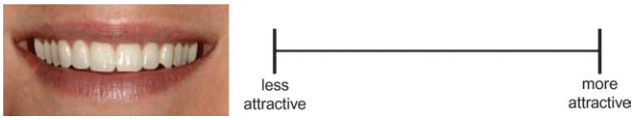

Figure 4 Example of a smile from the survey (M1–M1 BC ratio 0.92). Survey respondents judged smiles by marking attractiveness rating on 100 mm visual analogue scale.

The two duplicated smiles (M1–M1 0.84 and M1–M1 0.92) were used to evaluate the reliability of the attractiveness ratings for orthodontists and laypeople. Paired sample tests showed there were no systematic errors in attractiveness ratings. The method error for orthodontists ranged from 11.0 per cent for the M1–M1 0.84 smile to 14.6 per cent for the M1–M1 0.92 smile, and for laypeople from 17.3 to 23.1 per cent, respectively.

Results

Overall, orthodontists and laypeople preferred smiles with smaller BCs. Orthodontists preferred M1–M1 smiles while laypeople preferred PM2–PM2 smiles. There were no significant gender or age effects on attractiveness ratings of smiles.

Orthodontist preferences

With regard to symmetrical smiles, orthodontists preferred M1–M1 smiles without BCs. They generally preferred M1–M1 smiles over PM2–PM2 smiles when the BC ratios were larger, but they preferred PM2–PM2 smiles when BCs were smaller (Figure 5). The M1–M1 1.00 smile was rated most attractive, but there was no significant difference between it and the M1–M1 0.96 smile; the M1–M1 1.00 smile was significantly more attractive than the M1–M1 0.92 smile. The PM2–PM2 0.84 smile was significantly less attractive than all smiles above it and significantly more attractive than the M1–M1 0.84 smile.

Figure 6 shows that the attractiveness ratings of asymmetrical smiles were typically midway between the symmetrical ratios most closely approximating the asymmetrical BC ratios (i.e. PM2–PM2 0.50/0.50, 0.46/0.50, 0.48/0.48). This pattern was consistent except for the M1–M1 0.46/0.50 and M1–M1 0.46/0.48 smiles; both were rated less attractive than the symmetrical smiles nearest to them. However, the asymmetries used in this study only marginally reduced attractiveness; M1–M1 0.46/0.48 was the only asymmetric ratio that was significantly ($P < 0.05$) different than the two most closely corresponding symmetric ratios. The BC ratio was more important in determining the attractiveness of smiles than symmetry, but orthodontists did detect asymmetry in some smiles and rated them as less attractive than their closest symmetrical neighbours.

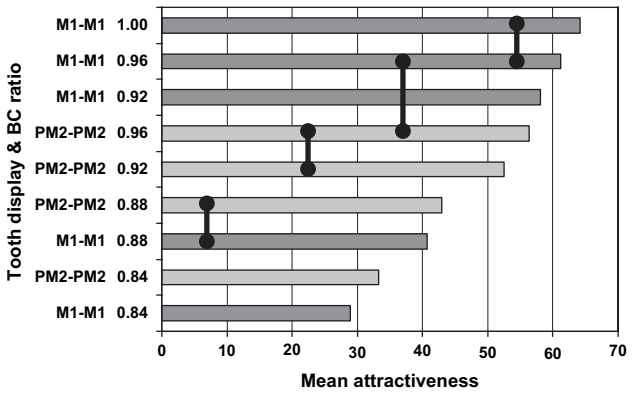

Figure 5 Comparison of symmetrical smile attractiveness for orthodontists according to teeth displayed and buccal corridor ratio based on a scale of 1–100 (Barbells connect smiles between which there were no significant differences).

Layperson preferences

With regard to symmetrical smiles, laypeople preferred PM2–PM2 smiles with small or no BC (Figure 7). The PM2–PM2 0.96 smile was rated most attractive, but did not differ significantly from the M1–M1 1.00 smile; the PM2–PM2 0.96 smile was significantly more attractive than the PM2–PM2 0.92 smile. There were no significant differences between the six smiles ranging from the M1–M1 1.00 to the PM2–PM2 0.84 smile (Figure 6). The two least attractive smiles were the M1–M1 0.88 and 0.84 smiles. The M1–M1 0.84 smile was significantly less attractive than all other smiles. Laypeople preferred PM2–PM2 smiles over M1–M1 smiles with BC ratio of 0.96, 0.88, and 0.84.

Laypeople also rated the attractiveness of asymmetrical smiles midway between the symmetrical smiles nearest to them in terms of BC ratios, i.e. M1–M1 0.50/0.50, 0.46/0.50, and 0.48/0.48. This pattern was consistent except for the PM2–PM2 0.46/0.48 and PM2–PM2 0.46/0.44 smiles, both of which were rated more attractive than the symmetrical smiles nearest to them, but the differences were not statistically significant. For laypeople, the BC ratio was more important in determining the attractiveness of the smile than symmetry.

Inter-group comparisons

Orthodontists reported M1–M1 smiles with BC ratios of 0.92 and larger to be significantly more attractive than laypeople (Table 2). Laypeople reported the M1–M1 smile with BC ratio of 0.84 to be significantly more attractive than orthodontists. Group differences for the PM2–PM2 smiles were smaller. Laypeople reported three out of four PM2–PM2 smiles as more attractive than orthodontists, but only the difference for the 0.84 smile was statistically significant.

While orthodontists found most asymmetrical M1–M1 smiles to be more attractive than laypeople, only the 0.46/0.50 smile showed statistically significant differences (Table 3).

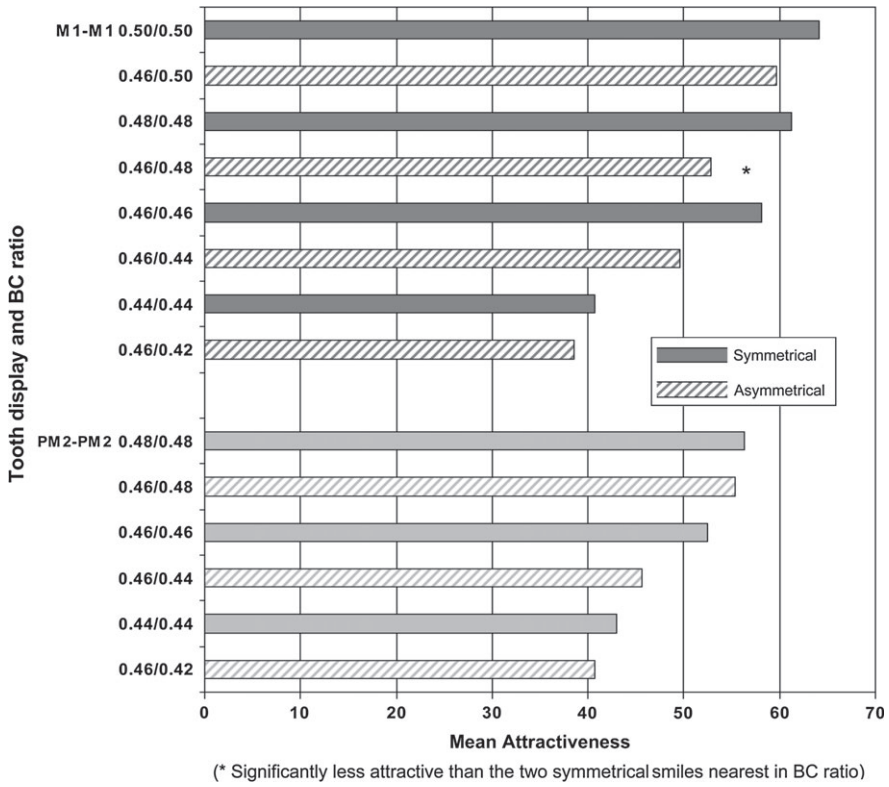

Figure 6 Comparison of attractiveness of asymmetrical smiles and symmetrical smiles [nearest to asymmetrical smile's buccal corridor (BC) ratio] for orthodontists according to teeth displayed and BC ratio based on a scale of 1-100.

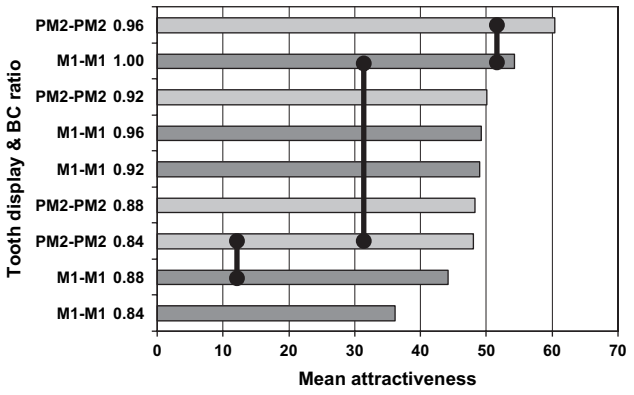

Figure 7 Comparison of symmetrical smile attractiveness for laypeople according to teeth displayed and buccal corridor ratio based on a scale of 1–100 (Barbells connect smiles between which there were no significant differences).

Similarly, laypeople reported asymmetrical PM2–PM2 smiles as more attractive than orthodontists, but the differences were only significant for the 0.46/0.44 smiles.

Discussion

This study, which simply addressed one of the numerous factors determining smile aesthetics, indicates that both orthodontists and laypeople prefer smiles with no or small BCs over those with large BCs. This agrees with the opinions of many other authors (Dierkes, 1987; Blitz, 1997; Morley and Eubank, 2001; Sarver, 2001; Sarver and Ackerman, 2003) that small BCs are more attractive, and also with the findings of Moore *et al.* (2005) that laypeople prefer smiles with no or small BCs. However, this is the first scientific study to show that orthodontists also prefer smiles with smaller or no BCs. Research indicating that BCs do not impact on attractiveness has been based on inter-canine widths (which usually do not adequately reflect the width of the dental arch), did not control for possible confounders of smile aesthetics (multiple patients with different attributes, variable smile intensity; variable lighting, etc.), or failed to compare smiles known to have different BC sizes (Hulsey, 1970; Johnson and Smith, 1995; Kim and Gianelly, 2003; Roden-Johnson *et al.*, 2005). Importantly, both the current study and that by Moore *et al.* (2005) altered only the BC ratio from smile to smile, which eliminated the possibility of other confounding aesthetic variables that could influence perceptions.

Laypeople were not as discriminating as orthodontists regarding BC size and smile attractiveness. Laypeople's ratings separated symmetrical smiles into only four groups, with the largest group, the midrange, including six smiles (Figure 6). In contrast, orthodontists separated the smiles

Table 2 Comparisons in smile attractiveness between orthodontists and laypeople according to teeth displayed and buccal corridor (BC) ratio.

BC ratio	Orthodontists		Laypeople		*t*-test comparisons	
	Mean	SD	Mean	SD	*F*	Significance
M1–M1 tooth display						
1.00	64.14	22.97	54.23	28.92	4.605	0.033
0.96	61.19	20.67	49.27	26.71	7.268	0.008
0.92	58.10	19.74	48.99	24.08	11.204	0.001
0.88	40.66	21.11	44.17	28.05	0.730	0.394
0.84	28.88	21.66	36.11	27.85	4.183	0.042
PM2–PM2 tooth display						
0.96	56.35	22.24	60.45	23.74	1.261	0.263
0.92	52.45	20.60	50.01	24.68	0.123	0.726
0.88	42.94	20.21	48.30	23.93	0.971	0.326
0.84	33.25	19.86	48.02	27.67	13.444	<0.001

Table 3 Comparisons in smile attractiveness between orthodontists and laypeople according to teeth displayed and asymmetrical buccal corridor (BC) ratio.

BC ratio		Orthodontists		Laypeople		*t*-test comparisons	
Left	Right	Mean	SD	Mean	SD	*F*	Significance
6–6 tooth display							
0.46	0.50	59.63	19.27	49.50	26.37	7.748	0.006
0.46	0.48	52.80	20.07	47.51	26.16	0.022	0.881
0.46	0.44	49.58	21.71	43.14	25.68	1.308	0.254
0.46	0.42	38.52	21.02	40.23	28.60	0.486	0.487
5–5 tooth display							
0.46	0.48	55.36	20.10	61.01	21.50	1.726	0.191
0.46	0.44	45.59	20.02	52.79	25.30	4.227	0.041
0.46	0.42	40.72	21.39	45.40	24.97	1.105	0.295

into six different groups and no smiles within any group varied by more than 0.04 BC ratio units (Figure 4). Additionally, the error variance for attractiveness ratings was 6–9 per cent greater for laypeople than for orthodontists. These results corroborate the findings of Kokich *et al.* (1999), who found that orthodontists detected smaller deviations in digitally altered smiles than laypeople. Because orthodontists are trained to focus on smiles and spend more time evaluating smiles, they might be expected to detect smaller differences than laypeople.

Since smaller BCs were perceived to be more attractive than larger BCs, orthodontists might consider maximizing maxillary width when it does not compromise other treatment goals. Traditionally, it has been thought that the maxillary arch should only be expanded when it is narrow in relation to the mandibular arch. Expansion may also be appropriate for adults with excessive lingual crown torque of the mandibular molars or for mixed-dentition patients with mild to moderate crowding that can be resolved with a mandibular lip bumper and maxillary expansion treatment (Ferris *et al.*, 2005; Solomon *et al.*, 2006). Importantly, these findings should not be used to justify routine expansion. This study was designed to focus on one aesthetic factor; orthodontists typically depend on multiple factors when making treatment decisions. Orthodontic stability, functional occlusion, and periodontal health must take precedence over the aesthetic differences identified. Moreover, smiles with average BCs, although less attractive, are not considered to be unattractive (Hulsey, 1970; Johnson and Smith, 1995; Kim and Gianelly, 2003).

Orthodontists tended to prefer M1–M1 smiles that displayed 12 teeth and laypeople PM2–PM2 smiles that displayed 10 teeth. While the majority of smiles normally display six or eight teeth (Tjan *et al.*, 1984), a positive relationship between the number of teeth in a smile and smile attractiveness has been reported (Johnson and Smith, 1995; Dunn *et al.*, 1996; Moore *et al.*, 2005). Most studies have not reported the specific numbers of teeth displayed, making direct comparison with the current results impossible. Importantly, there appears to be a limit for laypeople, who prefer smiles with 10 teeth over those with 12 teeth. This possibly reflects the fact that a smile with 12 teeth is rare (Tjan *et al.*, 1984) and laypeople are not used to seeing that many teeth.

The BC ratio had a greater impact on smile attractiveness than mild BC asymmetry. This agrees with the literature showing that mild facial asymmetry does not influence facial attractiveness and may actually be beneficial (Swaddle and Cuthill, 1995; Kowner, 1996). For example, it has been shown that 4.0 mm of dental midline deviation is required before orthodontists perceive asymmetry, which laypeople never perceive (Kokich *et al.*, 1999). The asymmetrical smiles in the current study had BCs that ranged 2 SD above and below average, but the actual asymmetry was only 8 per cent, which qualifies as a relatively mild asymmetry. Asymmetries in the current study were most likely not perceived by laypeople because they were mild. Orthodontists were more perceptive to asymmetries, which may again be due to their education and the clinical expertise they develop in evaluating smiles.

The results indicate that gender and age do not affect the perception of BC size. The lack of gender difference agrees with surveys of laypeople evaluating smile aesthetics (Brisman, 1980; Dunn *et al.*, 1996). While males and females agree on factors considered to be attractive, it has been shown that females are more sensitive to changes in those factors (Perrett *et al.*, 1999; Moore *et al.*, 2005). Either the gender difference for BC size was too small for the current study to detect, or it does not apply to BC size. There were also no differences in how the various age groups perceived BC size, which corresponds with reports of overall facial attractiveness. Judges as young as 7 years of age have been shown to agree with adults concerning attractiveness ratings (Cross

and Cross, 1971; Cavior and Lombardi, 1973; Kissler and Bauml, 2000). These studies suggest that preferences for facial attractiveness may develop early in life and are maintained into adulthood.

Finally, it is important to emphasize the limitations of this study. As the dental arch is expanded (whether as in this study or in actual clinical practice) more of the mesio-distal dimension of a tooth becomes visible. Therefore, the canine and posterior teeth in the PM2–PM2 smiles appeared larger than the same teeth in the M1–M1 smiles. Future investigations should utilize three-dimensional techniques to alter the BC and more precisely model the effects of arch expansion and tooth appearance. In this study, and others that digitally altered BCs (Moore *et al.*, 2005; Roden-Johnson *et al.*, 2005), the BCs start rather abruptly as dark spaces distal to the last posterior teeth, when in reality they are not sharply defined (Lombardi, 1973). Because BCs were difficult to produce digitally, the validation portion of this study, indicating that the BCs did not appear unnatural, was deemed to be essential. Even though the photographs were randomized, it is possible that there was an order effect. This could have been controlled by randomizing the order for each judge, which is feasible with an automated survey.

Conclusions

1. Laypeople and orthodontists prefer smiles with small or no BCs.
2. Laypeople are less discriminating than orthodontists in their perceptions of BC size.
3. Laypeople tended to prefer PM2–PM2 (10 teeth) smiles; orthodontists tended to prefer M1–M1 (12 teeth) smiles.
4. BC ratio has more impact on smile attractiveness than mild asymmetry.
5. There are no gender or age group differences in BC attractiveness ratings.

Address for correspondence

Professor Peter H. Buschang
Department of Orthodontics
Baylor College of Dentistry
3302 Gaston Avenue
Dallas
Texas 75246
USA
E-mail: phbuschang@bcd.tamhsc.edu

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