Original Article

Effects of transverse relationships between maxillary arch, mouth, and face on smile esthetics

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ABSTRACT

Objective: To identify the ideal ratios between the widths of the maxillary arch, mouth, and face, respectively, and to determine the range of acceptable esthetic variations based on these ideal ratios.

Materials and Methods: A photograph of a young female with a harmonious smile was selected and digitally altered to produce two sets of images. The first image showed an altered intercanine width, while the second one showed an altered oral fissure breadth. These alterations were independently rated by judges, including 23 orthodontists and 30 undergraduates. The Mann-Whitney *U*-test was used to compare the scores given by male and female judges and those given by professional and nonprofessional judges.

Results: The following ideal transverse ratios were determined: intercanine width/oral fissure breadth, 0.638; oral fissure breadth/interparopia width: the distance between left and right paropia, 0.617; and intercanine width/face width at the level of the labial commissures, 0.300. A range of −10% to +10% was proposed as the thresholds of esthetic smile evaluations. It was shown that gender of the raters had no effect on the rating of photographs, nor were there any statistically significant differences between the professional and nonprofessional judges' ratings.

Conclusions: Balanced transverse relationships in the facial region are important for smile esthetics, and there is a wide range of esthetically acceptable variations in the transverse relationships between the maxillary arch, mouth, and face. (*Angle Orthod.* 2016;86:135–141.)

KEY WORDS: Smile esthetics; Transverse relationship; Orthodontics

INTRODUCTION

It has been said that facial attractiveness is defined more by the smile than by soft tissue relationships.[1] Patients often consider an attractive smile as a major criterion defining the success of any dental interventions,[2] although the achievement of a well-balanced smile can be challenging because of the subjectivity of evaluation.[3] It is important to evaluate not only the face but also the effect of the dentition on the appearance of the smile. To date, a dearth of evidence has prevented an adequate understanding of the esthetically harmonious transverse dimensions of the smile. Therefore, it is necessary to create general guidelines to aid clinicians in optimizing smile esthetics while satisfying other treatment goals. This study focuses on the ideal ratio between the maxillary arch, mouth, and face and their corresponding acceptable range of deviations.

Smile analysis completes the assessment of a patient's esthetic goals.[4–6] The parameters evaluated during this analysis include posed smile,[7] transverse smile dimension,[8–10] position of the anterior teeth,[11,12] smile arc characteristics,[13,14] and vertical relationship

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of the gingival margins.[15] In clinical practice, the transverse width of the smile appears to be an important indicator in smile analysis. When the arch form is narrow or collapsed, the smile may also appear narrow, resulting in unsatisfactory transverse smile characteristics.[16] Frush and Fisher[17] believed that a wide smile was an unnatural smile, leading to what they termed a *denture face*.[17] Buccal corridors, represented by negative or *black spaces* between the buccal surfaces of the posterior teeth and the inner wall of the cheek, appear when an individual smiles[17] and are related to the width of the dental arch and torque of the posterior teeth.[18] Different investigators have reported on the esthetic value of buccal corridors, which range from no esthetic value[19,20] to outright unattractive when visible.[21–23] However, it has been reported that both minimal and excessive buccal corridors were considered the least attractive.[24] Several authors found that most individuals preferred a small black space at the sides of the smile over a large space,[25–27] while others believed that buccal corridors had little or negligible effects on smile esthetics.[14,19,28,29] Furthermore, buccal corridor width was reported to show an inverse correlation with intercanine and intermolar widths.[24,29]

Many scholars describe the need for certain smile proportions in order to harmonize the smile with the face.[30–32] Most studies have concerned themselves only with harmony between the lips and teeth and failed to consider the relationship between the mouth and face. To our knowledge, no studies to date have evaluated the esthetic effects of the transverse dimensions of the maxillary arch and mouth with regard to interparopia and facial widths. Therefore, clinicians should consider transverse balanced relationship between dental arches, mouth, and face when designing a smile. This study explores the ideal ratios between the maxillary arches, mouth, and face of a native Chinese female to provide cultural references for treatment planning and smile training for orthodontists, specifically addressing the ideal relationships between the widths of the dental arches, mouth, and lower face and the acceptable range of variations in these ratios.

MATERIALS AND METHODS

Informed consent for participation was obtained from each volunteer. This study was approved by the ethics committee of Sichuan University.

Photograph Selection

The sample size for this study was calculated using S-Size software (WHO version 2.021, World Health Organization, Geneva, Switzerland) to achieve statistically significant data at $\alpha = 0.05$ with a power of 90%. The generated sample size required a minimum of 10 subjects in each group. Two groups were created: a panel of orthodontists (14 men, 9 women) and a panel of undergraduates (15 men, 15 women). The orthodontists had practiced for at least 8 years at the Department of Orthodontics in Sichuan University. The undergraduates were all in their 20s and had studied at Sichuan University; they could represent the typical young patients seeking orthodontic treatment.[33] Fifty-three judges reviewed 12 photographs of 12 volunteers. Volunteer selection was restricted to the following criteria: (1) untreated Class I malocclusion and Class I skeletal pattern, (2) normal findings in hard tissue cephalometric analysis (Winceph 7.0, Winceph: Rise Corporation, Sendai, Japan), and (3) normal findings in soft tissue cephalometric analysis.[33] A Canon A630 digital camera (Canon: Canon Inc, Tokyo, Japan) was used to obtain frontal smile photographs from 12 female volunteers who met the above criteria All judges were asked to rate the

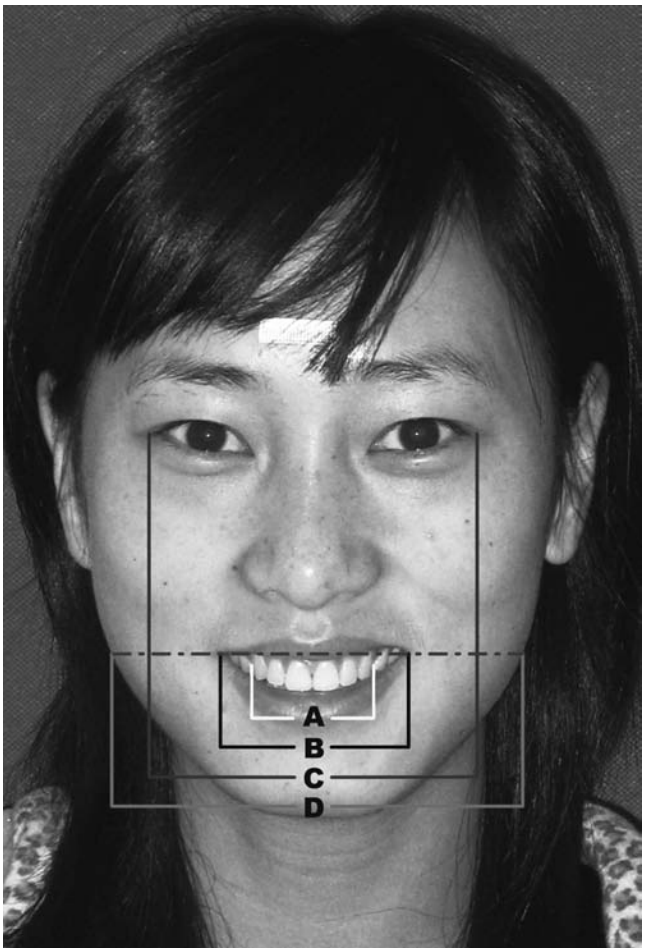

Figure 1. Original harmonious photograph of a smiling female with the measured ratios highlighted. (A) Intercanine width, (B) oral fissure breadth, (C) interparopia width, and (D) facial width at the levels of the labial commissures. Magnification, 1:1.05.

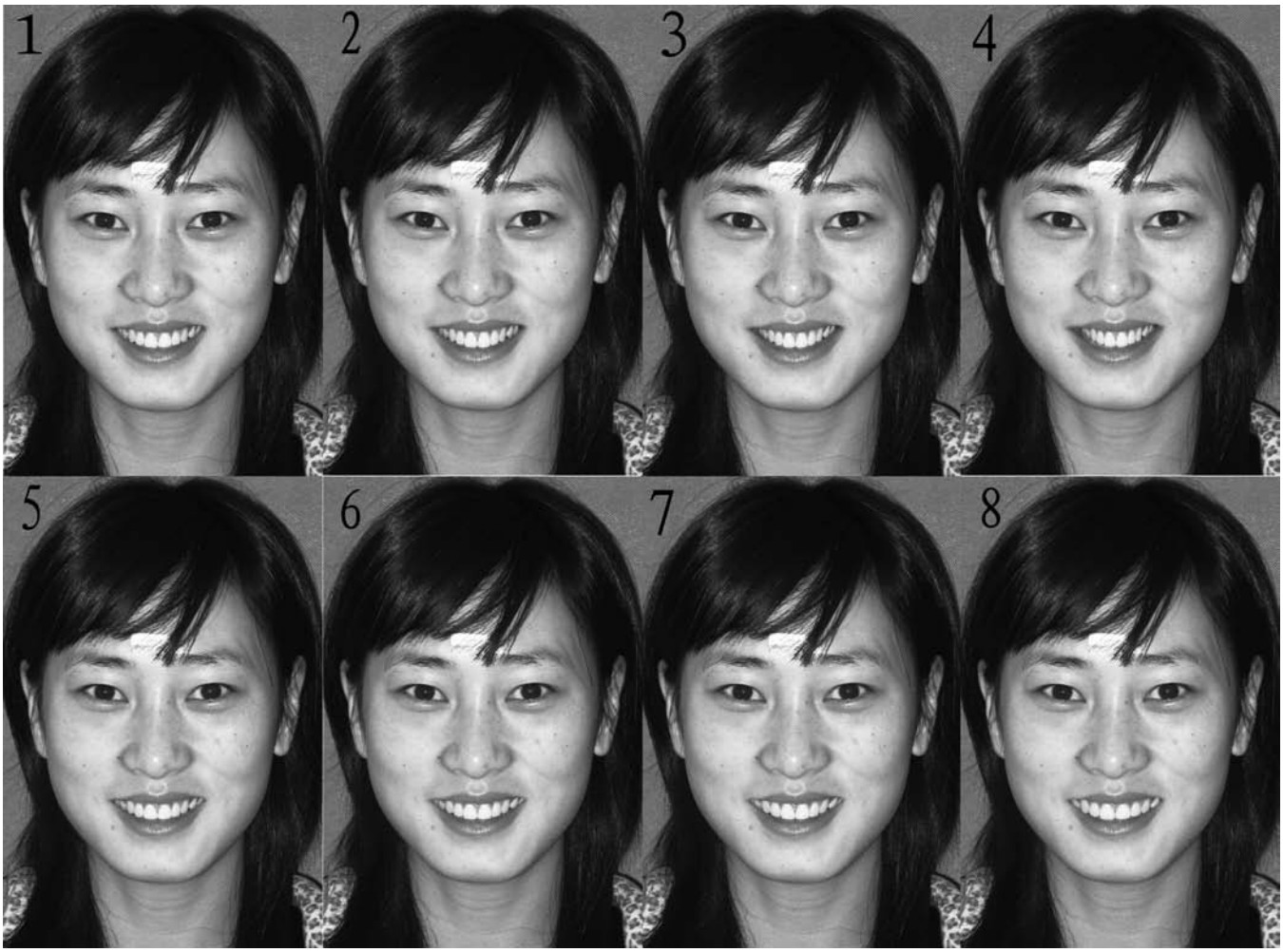

Figure 2. Variations in exposed maxillary arch. Eight photos were generated by changing each side of the exposed maxillary arch width on the original photo at 1-mm increments, to a maximum of ±4 mm. The oral fissure breadth remains unchanged.

attractiveness of each photograph and score them using the Numeric Rating Scale (NRS), which is an assembly of categorical values divided into five groups: most unpleasant (0–50), unpleasant (50–60), acceptable (60–70), pleasant (70–90), and most pleasant (90–100). Therefore, the volunteer whose pictures scored the highest was selected as the one with the most beautiful and harmonious facial esthetics (Figure 1).

Photograph Analysis and Editing

Four smile characteristics were measured in the original photograph (Figure 1): intercanine width, oral fissure breadth, interparopia width, and facial width at the level of the labial commissures. Ratios for common relationships between these parameters were calculated, and the photograph was edited with Photoshop CS2 (Photoshop: Adobe Systems Incorporated, San Jose, Calif, USA) in two ways. Figure 2 illustrates the generation of eight images created by altering the original photograph such that each side of the exposed maxillary arch width varied at 1-mm increments to a maximum of ±4 mm. The mouth width remained unchanged. Figure 3 illustrates the generation of eight such images.

Scoring

Figure 1 and the eight images comprising Figure 2 were placed into set 1 on slide 1. Figure 1 and the eight images comprising Figure 3 were placed into set 2 on slide 2. The images were arranged such that Figure 1 appeared in the center of both sets and the altered photographs appeared on either side according to increasing deviations from the original photograph. Thus, overall, two sets of images comprising nine different pictures each were selected. All the judges were asked to rate the attractiveness of each photograph again and score them using the NRS, as described above. In addition to rating the images, the judges selected two images in each set in which the facial features reached their personal unpleasantness

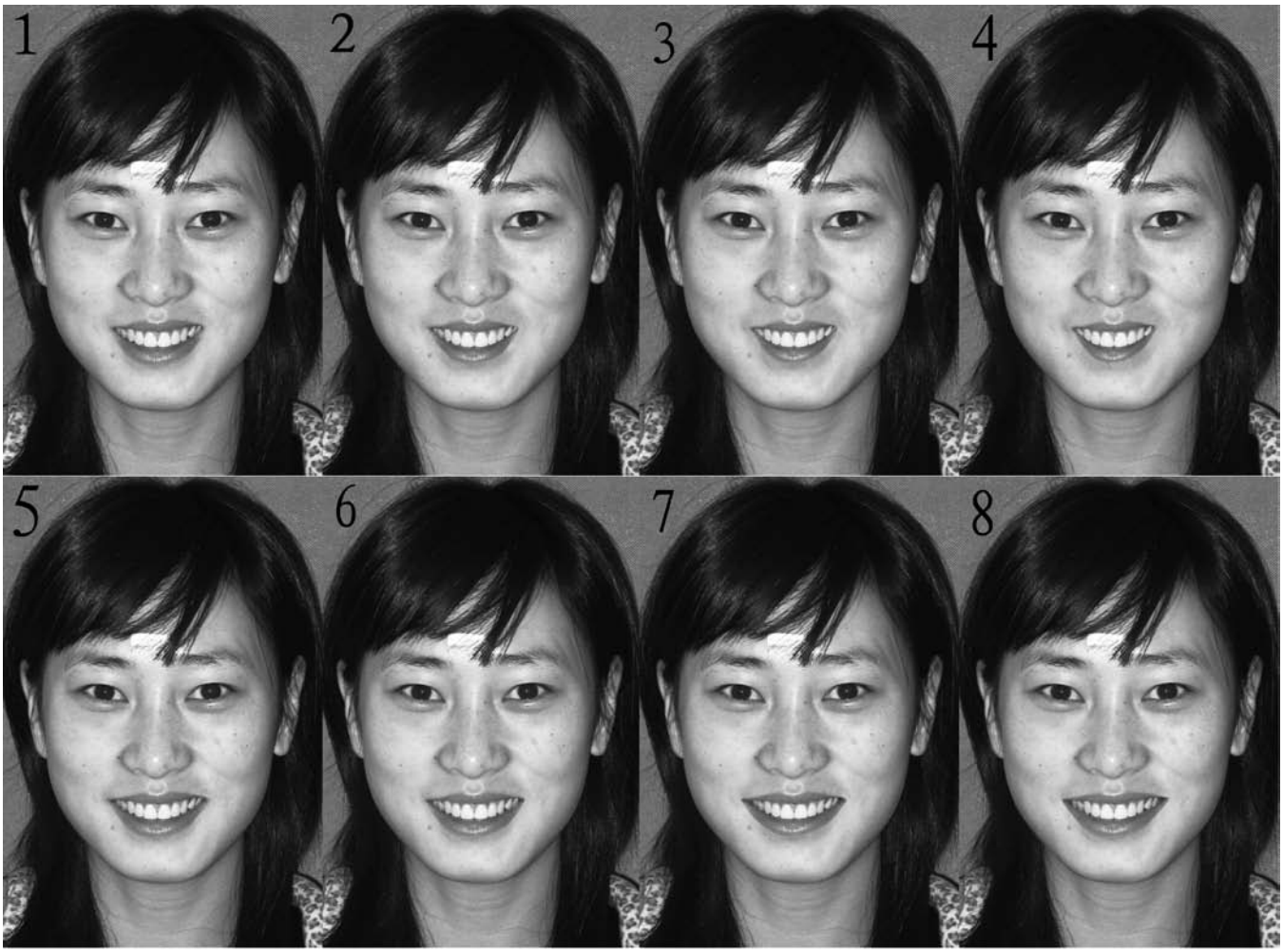

Figure 3. Variations in oral fissure breadth. Eight photos were generated by changing each side of the oral fissure breadth on the original photo at 1-mm increments, to a maximum of ±4 mm. The exposed maxillary arch remains unchanged.

threshold. The entire process was repeated after a month to ensure reliability of the scores.

Statistical Processing and Analysis

Individual scores for each image (18 images in total) were imported into a table in Microsoft Excel (version 2003 (Excel, Microsoft Corp, Redmond, Wash, USA). The mean scores, standard deviations, and 95% confidence intervals (CIs) were calculated for these images. Comparison between the acceptable images and the photographic alterations produced values used to construct a range deviating from the values of the original photograph, within which smile alteration remained esthetically acceptable. The intercanine widths and oral fissure breadths were measured on these images and used to calculate the acceptable range of deviations in the A:B, B:C, and A:D ratios (A, intercanine width; B, oral fissure breadth; C, interparopia width; D, facial width at the levels of the labial commissures).

The Mann-Whitney *U*-test was used to compare scores given by the male and female judges and by the professionals and nonprofessionals. Reproducibility among scores was tested using the κ value with a 95% CI.

RESULTS

Reliability

The κ value for interrater reliability was 0.82 (lower bound, 0.79; upper bound, 0.85; 95% CI) for the orthodontists and 0.77 (lower bound, 0.72; upper bound, 0.79; 95% CI) for the undergraduates. Both groups showed good reliability.

Transverse Measurements Using the Original Photograph

This study was based on commonly used transverse measurement sites on the original photograph of the most beautiful and esthetically harmonious volunteer

Table 1. Transverse Measurement Results of the Original Photo

	Mean (mm)	SD (mm)		Mean (%)	SD (%)
A*	35.24	0.47	A/B	63.80	0.53
B	55.24	0.85	B/C	61.71	0.85
C	89.51	0.42	A/D	30.00	0.49
D	117.47	0.38			

* A represents the intercanine width; B, the oral fissure breadth; C, the interparopia width; D, the face width on the commissure plane.

among 12 females (Figure 1). Table 1 shows the results of the transverse measurements. The A:B and B:C ratios were very close to the golden ratio. The favorable intercanine width was approximately 30% of the facial width at the level of the labial commissures.

Acceptability

The acceptability of increased and decreased arch widths and oral fissure breadths was calculated for the 53 judges (Figure 4). The threshold images reflected the general acceptability of four changes in smile esthetics. The acceptable deviation for arch width was −3.61 mm to +2.23 mm from the width on the original photograph, while that for oral fissure breadth was −2.58 mm to +3.72 mm from the breadth on the original photograph. Gender had no effect on rating of the photographs (Table 2). Also, there were no statistical differences between professional and non-professional judges on rating of the photographs (Table 3). Therefore, we combined the two groups for discussion purposes.

Acceptable Ranges of Deviations in Transverse Relationships

The acceptable ranges of deviations were calculated and used to determine ideal transverse relationships (Figure 5). The acceptable A:B ratio ranged from 0.573 to 0.678 (−11% to +7% change in arch width) and from 0.598 to 0.669 (−7% to +5% change in oral fissure breadth). These values deviated from the original values by approximately ±10%. When changes in the intercanine width or oral fissure breadth exceeded

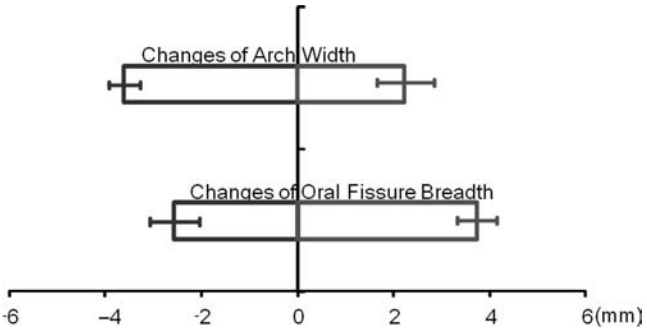

Figure 4. Acceptability of altered maxillary arch widths and oral fissure breadth. The acceptable deviation for arch width from the original value is −3.61 mm to +2.23 mm, while that for oral fissure breadth is −2.58 mm to +3.72 mm.

these ranges, the judges deemed the resulting images esthetically unpleasant. The acceptable B:C ratio ranged from 0.588 to 0.659, representing a deviation of approximately ±10% from the original values. The acceptable A:D ratio ranged from 0.269 to 0.319, representing a deviation of approximately ±10% from the original values.

DISCUSSION

In this study, we evaluated the most beautiful and harmonious smile selected from those of 12 female volunteers, identified the ideal ratios between the widths of the maxillary arch, mouth, and face, respectively, and determined the range of esthetically acceptable variations in these ideal ratios. Since ratios have a wider scope of application compared with normal measurements, our most important findings were standard ratios and their esthetically acceptable ranges of deviations. The most harmonious smile was demonstrated to exist within a range with a ±10% deviation from the standard values obtained from an ideal photograph. This implied that a range of acceptability exists in the transverse balanced relationships between the widths of the maxillary arch, mouth, and face. For all measurements, we found the acceptable ratios to fluctuate by ±10%. Furthermore,

Table 2. Mean Scores and SDs of Images With Different Intercanine Width as Rated by Male and Female, Expert and Nonexpert Judges

		Mean Score (±SD)			Mean Score (±SD)		
Image	Intercanine Width	Male	Female	*P* Value	Expert	Non-expert	*P* Value
1A	−4	53.6 ± 1.2	53.9 ± 1.3	.46	53.2 ± 1.4	53.7 ± 1.3	.48
1B	−3	64.7 ± 1.3	65.0 ± 1.5	.45	63.4 ± 1.2	64.2 ± 1.6	.26
1C	−2	68.2 ± 1.4	68.1 ± 1.4	.31	67.9 ± 1.0	68.5 ± 1.6	.31
1D	−1	76.2 ± 1.6	76.6 ± 1.4	.39	74.8 ± 1.1	75.6 ± 1.1	.28
1E (Original)	0	79.8 ± 1.5	80.0 ± 1.5	.52	80.1 ± 1.3	79.5 ± 1.7	.35
1F	+1	72.1 ± 1.4	71.8 ± 1.4	.23	71.8 ± 1.4	72.2 ± 1.3	.56
1G	+2	64.3 ± 1.5	64.7 ± 1.3	.43	65.1 ± 1.6	65.0 ± 1.4	.82
1H	+3	52.2 ± 1.3	52.1 ± 1.1	.58	51.8 ± 1.2	52.2 ± 1.2	.61
1I	+4	50.1 ± 1.1	50.6 ± 1.0	.32	51.0 ± 1.4	50.4 ± 1.6	.53

Table 3. Mean Scores and SD of Images With Different Oral Fissure Breadth as Rated by Male and Female, Expert and Nonexpert Judges

Image	Oral Fissure Breadth	Mean Score (±SD)		*P* Value	Mean Score (±SD)		*P* Value
		Male	Female		Expert	Nonexpert	
2A	−4	51.8 ± 1.3	52.5 ± 1.2	.23	52.3 ± 1.1	52.5 ± 1.4	.46
2B	−3	53.4 ± 1.2	54.1 ± 1.5	.30	54.2 ± 1.4	54.1 ± 1.3	.45
2C	−2	62.9 + 1.4	63.7 ± 1.1	.25	63.5 + 1.2	63.7 ± 1.5	.31
2D	−1	74.8 ± 1.2	74.2 ± 1.7	.45	74.3 ± 1.5	74.2 ± 1.2	.39
2E (Original)	0	82.5 ± 1.4	82.5 ± 1.4	.82	82.2 ± 1.1	82.5 ± 1.3	.52
2F	+1	87.2 ± 1.1	86.9 ± 1.3	.38	87.4 ± 1.3	86.9 ± 1.4	.23
2G	+2	74.2 ± 1.3	74.3 ± 1.0	.64	74.2 ± 1.5	74.3 ± 1.2	.43
2H	+3	67.9 ± 1.5	67.8 ± 1.1	.70	67.9 ± 1.1	67.8 ± 1.2	.58
2I	+4	58.5 ± 1.2	57.9 ± 1.2	.39	58.5 ± 1.2	57.9 ± 1.6	.32

there were no statistical differences between orthodontists and undergraduates when evaluating the photographs. Furthermore, gender did not influence the judges' acceptability of altered maxillary arch widths or oral fissure breadths.

This study also determined that the acceptable range of variations in the A:B ratio was considerably broad. Changes in the intercanine width and oral fissure breadth resulted in a pleasing smile within deviations of ±10% from the standard values. This confirms our hypothesis that a harmonious smile comprises certain proportions and that maxillary arch width is directly related to measurements of the surrounding soft tissue. Theoretically, smiles became unacceptable beyond this range. However, the acceptable range of deviations in the ratios between the widths of the maxillary arch, mouth, and face was considerably broad in this study, indicating that transverse relationships in most patients are within this range. The arches should not necessarily be expanded or contracted in every patient. Rapid maxillary expansion, for example, does not always benefit a patient's smile attractiveness. A narrower face can probably support a narrower arch, and vice versa, without compromising smile esthetics.

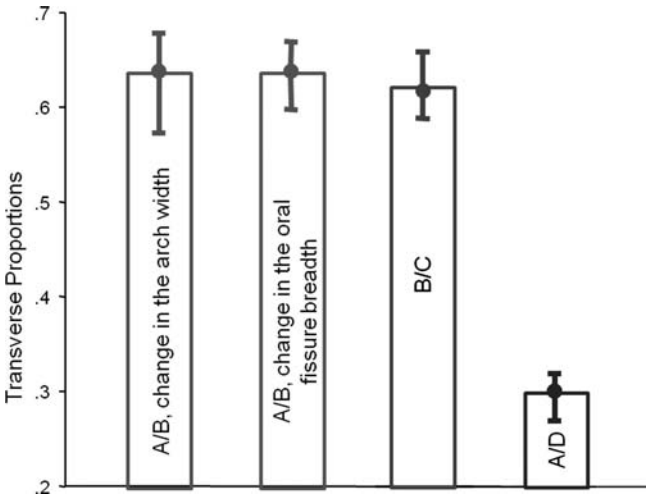

Figure 5. Acceptable deviations in transverse proportions. While the A:B and B:C ratios are considerably close to the golden ratio, the A:D ratio was 0.030, a range that deviates by ±10% from these standard values.

It is said that the average normal face does not always represent the most attractive face.[34] The analysis of 12 photographs of ordinary, young females by 53 judges in this study resulted in the selection of the typical Mongoloid beautiful smile. Selection of the best image from a representative sample resulted in a more natural standard than the generation of a composite average from photographs of models or actors.[34,35]

Ricketts's analysis of beautiful faces found a wide existence of golden ratios for facial esthetics.[36] Pan and Lu[37] reported that Mongoloids' Ocular Lip index was greater than the golden ratio. In our study, we found that the intercanine width and the oral fissure breadth ratio close to 0.618. We also found that the favorable intercanine width was approximately 30% of the facial width at the levels of the labial commissures. Therefore, golden ratios may be useful aids when assessing the transverse facial dimension.

CONCLUSIONS

- Balanced transverse relationships, particularly with regard to maxillary arch widths, are important when assessing the attractiveness of a smile.
- There is a wide range of esthetically acceptable variations in the transverse relationships between the dental arch, mouth, and face.
- Because the esthetically acceptable range is considerably wide, the maxillary arch should not necessarily be expanded or contracted in every patient, and decisions should be made depending on the individual case.

REFERENCES

1. Fields HW, Sarver DM, Proffit WR. *Contemporary orthodontics*. 5th ed. St. Louis, Mo: Elsevier/Mosby; 2013.
2. Samson GS, Fogle JG, Johnston LJ, Bowman SJ. The smile questionnaire. *J Clin Orthod*. 2010;44:177–180.

3. 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;128:690–696, 801.
4. Kessel SP. Smile analysis. *Am J Orthod Dentofacial Orthop*. 2003;124:11A.
5. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. *J Clin Orthod*. 2002;36:221–236.
6. Richards MR, Fields HW, Jr., Beck FM, Firestone AR, Walther DB, Rosenstiel S, Sacksteder JM. Contribution of malocclusion and female facial attractiveness to smile esthetics evaluated by eye tracking. *Am J Orthod Dentofac Orthop*. 2015;147:472–482.
7. Rigsbee OR, Sperry TP, BeGole EA. The influence of facial animation on smile characteristics. *Int J Adult Orthod Orthognath Surg*. 1988;3:233–239.
8. Cronin T. Excellence in orthodontics with a systematic approach smile design governed by stability concerns. Part I: transverse relationships. *Int J Orthod* (Milwaukee). 2007;18:43–45.
9. Fleming PS, Dibiase AT, Lee RT. Arch form and dimensional changes in orthodontics. *Prog Orthod*. 2008;9:66–73.
10. Maganzini AL, Schroetter SB, Freeman K. Improvement in smile esthetics following orthodontic treatment: a retrospective study utilizing standardized smile analysis. *Angle Orthod*. 2014;84:492–499.
11. Chu SJ, Tan JH, Stappert CF, Tarnow DP. Gingival zenith positions and levels of the maxillary anterior dentition. *J Esthet Restor Dent*. 2009;21:113–120.
12. Hayashida H, Ioi H, Nakata S, Takahashi I, Counts AL. Effects of retraction of anterior teeth and initial soft tissue variables on lip changes in Japanese adults. *Eur J Orthod*. 2011;33:419–426.
13. Akyalcin S, Frels LK, English JD, Laman S. Analysis of smile esthetics in American Board of Orthodontics patients. *Angle Orthod*. 2014;84:486–491.
14. Janson G, Branco NC, Fernandes TM, Sathler R, Garib D, Lauris JR. Influence of orthodontic treatment, midline position, buccal corridor and smile arc on smile attractiveness. *Angle Orthod*. 2011;81:153–161.
15. Guo J, Gong H, Tian W, Tang W, Bai D. Alteration of gingival exposure and its aesthetic effect. *J Craniofac Surg*. 2011;22:909–913.
16. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification:smile analysis and treatment strategies, *Am J Orthod Dentofacial Orthop*. 2003;124:116–127. (pt 2)
17. Frush JP, Fisher RD. The dynesthetic interpretation of the dentogenic concept. *J Prosthet Dent*. 1958;8:558–581.
18. Meyer AH, Woods MG, Manton DJ. Maxillary arch width and buccal corridor changes with orthodontic treatment:differences between premolar extraction and nonextraction treatment outcomes. *Am J Orthod Dentofacial Orthop*. 2014;145:207–216. (pt 1)
19. 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;127:343–350.
20. 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;76:557–563.
21. 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;7:56–65.
22. Springer NC, Chang C, Fields HW, et al. Smile esthetics from the layperson's perspective. *Am J Orthod Dentofacial Orthop*. 2011;139:e91–e101.
23. Rufenacht CR. *Fundamentals of Esthetics*. Chicago: Quintessence; 1990.
24. Oshagh M, Zarif NH, Bahramnia F. Evaluation of the effect of buccal corridor size on smile attractiveness. *Eur J Esthet Dent*. 2010;5:370–380.
25. Dunn WJ, Murchison DF, Broome JC. Esthetics:patients' perceptions of dental attractiveness. *J Prosthodont*. 1996; 5:166–171.
26. Morley J, Eubank J. Macroesthetic elements of smile design. *J Am Dent Assoc*. 2001;132:39–45.
27. Moore T, Southard KA, Casko JS, Qian F, Southard TE. Buccal corridors and smile esthetics. *Am J Orthod Dentofacial Orthop*. 2005;127:208–213, 261.
28. Ritter DE, Gandini LG, Pinto AS, Locks A. Esthetic influence of negative space in the buccal corridor during smiling. *Angle Orthod*. 2006;76:198–203.
29. Tikku T, Khanna R, Maurya RP, Ahmad N. Role of buccal corridor in smile esthetics and its correlation with underlying skeletal and dental structures. *Indian J Dent Res*. 2012;23:187–194.
30. Lombardi RE. The principles of visual perception and their clinical application to denture esthetics. *J Prosthet Dent*. 1973;29:358–382.
31. Al–Marzok MI, Majeed KR, Ibrahim IK. Evaluation of maxillary anterior teeth and their relation to the golden proportion in Malaysian population. *BMC Oral Health*. 2013;13:9.
32. Ricketts RM. Divine proportion in facial esthetics. *Clin Plast Surg*. 1982;9:401–422.
33. Cao L, Zhang K, Bai D, Jing Y, Tian Y, Guo Y. Effect of maxillary incisor labiolingual inclination and anteroposterior position on smiling profile esthetics. *Angle Orthod*. 2011;81:121–129.
34. Hunt O, Johnston C, Hepper P, Burden D, Stevenson M. The influence of maxillary gingival exposure on dental attractiveness ratings. *Eur J Orthod*. 2002;24:199–204.
35. Schlosser JB, Preston CB, Lampasso J. The effects of computer-aided anteroposterior maxillary incisor movement on ratings of facial attractiveness. *Am J Orthod Dentofac Orthop*. 2005;127:17–24.
36. Ricketts RM. Perspectives in the clinical application of cephalometrics: the first fifty years. *Angle Orthod*. 1981;51: 115–150.
37. Pan BH, Lu KY. Computer measurement and analysis of facial aesthetics. *Chinese Journal of Medical Aesthetics and Cosmetology*. 1995;4:70–73.