Original Article

Does facial growth pattern affect the perception of lower facial asymmetry?

Ece Basal[a]; Ismail Cevik[b]; Yasemin Bahar Acar[c]; Fulya Özdemir[d]

ABSTRACT

Objectives: To investigate the influence of vertical facial type on esthetic perception of lower facial asymmetry as evaluated by orthodontists, dentists, and laypeople.

Materials and Methods: Three adult females were selected with normal growth patterns (NGP), vertical growth patterns (VGP), and horizontal growth patterns (HGP). Frontal photographs were made symmetric and digitally altered, rotating the lower facial third clockwise, ranging from 0° to 6° in 1° increments. A web-based survey was designed with 24 images (eight images for each model) in random order. Each image was rated using a scale ranging from 0 (unattractive) to 10 (the most attractive) by 75 orthodontists, 73 dentists, and 78 laypeople. Kruskal-Wallis test was used to determine whether differences among groups were significant. Pairwise comparisons were made with Mann-Whitney *U* test. The significance level was set at $P = .05$.

Results: In NGP, orthodontists and dentists could recognize slighter deviations (2°), while deviations in VGP and HGP under 3° were not recognized by all groups. Severe deviations ($\geq$4°) were distinguished better in HGP by orthodontists and laypeople. In VGP and NGP, there was no significant difference over 4°.

Conclusions: Growth pattern has a significant influence on perception of lower facial asymmetry. Less severe asymmetry can be detected better in NGP. In severe degrees, increments of asymmetry can be perceived more in HGP by orthodontists and laypeople. (*Angle Orthod*. 2024;94:455–461.)

KEY WORDS: Facial asymmetry; Perception; Vertical dimension

INTRODUCTION

Every organism in nature exhibits some degree of asymmetry. Though perfect symmetry is quite rare,[1] it is an essential esthetic determinant of orthodontic assessment. Facial asymmetry should be examined by dental professionals in terms of soft and hard tissues or dental structures.[2] During assessment, special attention should be paid to symmetry of the chin, gonial regions, and contours of the mandibular corpus.[3] Apart from clinical examination, casts, two-dimensional (2D; photographs, posteroanterior cephalograms), and three-dimensional imaging techniques (stereophotogrammetry, cone-beam computed tomography) are supplementary diagnostic tools for evaluating asymmetry.[4] Additionally, it should be considered that more severe facial asymmetry can be associated with serious functional problems as well as esthetic dissatisfaction. There are three options for treatment of jaw discrepancy accompanied by severe malocclusion: growth modification (if growth potential exists), camouflage treatment, or orthognathic surgery combined with orthodontics. For camouflage treatment, careful assessment of facial esthetics and functional stability is needed. The orthodontist should determine the best therapeutic approach. If such treatment yields optimal occlusion at the sacrifice of compromised facial esthetics, it cannot be deemed successful.[5]

The amount of patient dissatisfaction may be a significant determinant when deciding the most appropriate treatment modality: camouflage or surgical treatment, especially for borderline cases. When concern of asymmetry is beyond acceptable limits in adults, the psychosocial effect caused by an unesthetic appearance should not be overlooked.[5] In that case, consideration of orthognatic surgery combined with orthodontic treatment might be beneficial.[6] From the patient's standpoint, transverse

[a] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey.
[b] PhD Student, Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey.
[c] Associate Professor, Department of Orthodontics, Faculty of Dentistry, Marmara University, Istanbul, Turkey.
[d] Professor, Department of Orthodontics, Faculty of Dentistry, Istanbul Saglik ve Teknoloji University, Istanbul, Turkey.
Corresponding author: Dr Ece Basal, Department of Orthodontics, Faculty of Dentistry, Marmara University, Basibuyuk Street 9/3, 34854, Basibuyuk, Maltepe, Istanbul, Turkey
(e-mail: eceabuhan@hotmail.com)

Accepted: January 2024. Submitted: September 2023.
Published Online: March 11, 2024

deviations can be more noticeable than profile irregularities, since patients see the problem whenever they look in the mirror.[7] Additionally, with a growing demand for having a more photogenic appearance, some individuals may avoid being photographed from the frontal view, instead preferring their better-perceived half faces to be viewed from an angle. Contemporary treatment planning emphasizes consideration of patient perception of dentofacial structures as a primary success criterion. While setting therapeutic goals, patients should participate in decision-making processes along with the doctor.[5]

Anteroposterior and vertical facial relationships have been studied extensively. However, perhaps as a result of increasing esthetic expectations, alterations in the transverse plane have received increased attention in the last decade.[8]

Among sagittal malocclusions, Class III cases were found to exhibit facial asymmetry more frequently,[9] while Class II individuals were found to have significantly less asymmetry compared to other subgroups.[10] Using another approach, the prevalence was equally distributed among Class I, II, and III individuals.[11] Regarding the vertical aspect, the lower facial third was found to be the most affected by deviations, with an increased prevalence in hyperdivergent patients.[7]

In the literature, studies have examined perceptions of asymmetry by laypeople, general dental practitioners, and orthodontists at macro-, mini-, and microesthetic levels.[12] When macroesthetics were evaluated in perception studies, only a small number of them investigated lower facial asymmetry.[13–16] However, none of them considered the effect of different vertical skeletal patterns on perception of asymmetry. Therefore, the primary aim of this study was to examine if vertical skeletal growth pattern affected the perception of asymmetry in the lower facial third. The secondary aim was to investigate the clinical threshold of asymmetry perception in orthodontists, dentists, and laypeople for various facial types.

MATERIALS AND METHODS

Ethical approval for this study was granted by the Ethical Committee of Marmara University, Faculty of Dentistry (Protocol No 2022-103). Three female volunteers with normal (NGP), vertical (VGP), and horizontal (HGP) growth patterns were selected according to results of cephalometric analyses; sum of inner angles, Jarabak ratio, ANS-Me/N-Me, and maxillary height values were used to define growth patterns. Signed informed consent was obtained. The models had a skeletal Class I relationship (ANB:2°), no dysmorphic facial features, and no previous history of orthodontic treatment.

Frontal photographs of models were taken in natural head position with relaxed facial expression. Subjects were instructed to tie their hair back and have no make-up or adornments. Photographs were edited using Adobe Photoshop 2020 (Adobe Systems, California, USA). Any skin flaws were removed. Mirror images of one-half of the photographs were combined to create a symmetric template. Four soft tissue points (subnasale, left and right soft tissue gonion, and soft tissue menton) were selected, as previously described by Jarosz et al.,[13] and used to outline the entire lower facial third to be rotated to the right side. By rotating the lower facial third of photographs clockwise in 1° increments, seven photographs per individual were obtained with deviations ranging from 0° to 6°. Two-digit designations were assigned to images; the first digit identified the growth pattern as N/V/H (normal, vertical, horizontal) and the second digit indicated degree of rotation (0°–6°). Each model was also photographed with a ruler to calibrate images. Then, the lower facial height and corresponding milimetric deviation amounts on the x-axis were measured (Figure 1, Table 1).

An online survey was prepared with eight images for each model (24 images total). To evaluate intraexaminer relability, 0° images were used twice for each series of images. Below each image, a visual analog scale graded from 0 to 10 (0: unattractive; 10: the most attractive) was included. Images of each model were shown on separate pages in random order (Figure 2). To avoid bias, participants were told to assess each model individually. The Turkish Orthodontic Society contacted 2240 members via e-mail and online questionnaire forms were sent to approximately 300 dentists and 300 laypeople via Whatsapp. A total of 226 people participated in the survey, including 75 orthodontists, 73 dentists, and 78 laypeople. Laypeople with no previous orthodontic treatment, dentists who were actively in clinical practice, and orthodontists who were specialists in orthodontics were included.

Statistical Analysis

Post-hoc power analysis was conducted using G*Power software (version 3.1.9.2, Heinrich-Heine-University Düsseldorf, Germany). The calculation revealed that 226 participants allowed for 92.6% power and an alpha of 0.05 to obtain an effect size of 0.25. Statistical analyses were performed using IBM SPSS Statistics Software, 25.0 (Statistical Packages of Social Sciences, IBM Corp., NY, USA). Cronbach's alpha coefficient was used to assess reliability. To assess intergroup differences, scores were analyzed using Kruskal-Wallis test in addition to post-hoc Bonferroni test. Pairwise comparisons were performed using Mann-Whitney *U* test to identify which photos differed, and Bonferroni adjustment was applied to *P* values.

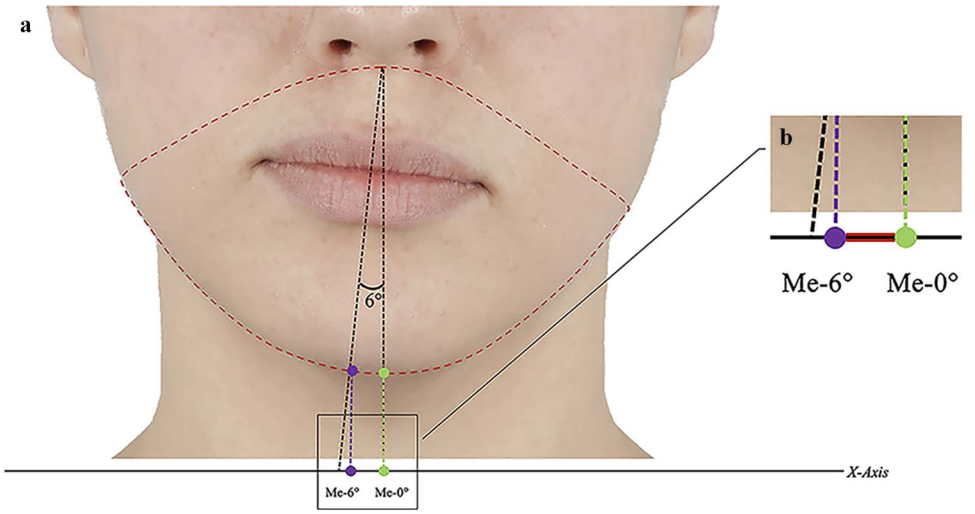

Figure 1. (a) Digital alteration of the lower face (chin, accompanied by subnasale, right-left soft tissue gonion regions) in NGP with 6° deviation. (b) The horizontal distance between symmetric and digitally altered Menton points (Me-0° and Me-6°), shown with red line on x-axis.

RESULTS

Age and sex distributions showed no significant intergroup differences. The range of 0.809 to 0.897 in Cronbach alpha values indicated good intrarater reliability.

Kruskal-Wallis test showed that all groups had statistically significant differences (Tables 2, 3, and 4). Tables 2, 3, and 4 also show pairwise comparison results. It was observed that, as degree of deviation increased from 0° to 6°, rating scores decreased in all cells. Statistically significant pairwise comparisons were found between 0° and 3° in HGP and VGP for all evaluator groups and in NGP for laypeople. In these groups, scores between 0° and 1°, 0° and 2°, 1° and 2° did not show a significant difference. In the remaining groups, namely in NGP for orthodontists and dentists, rating scores showed a significant decrease at an earlier deviation: between 0° and 2°. Therefore, it was interpreted that the overall threshold level for the first detection of asymmetry was 3° while, in NGP, it decreased to 2° for dental professionals. Table 5 shows exact *P* values for these deviations and their milimetric correspondence of chin displacement.

Table 1. Degree of Chin Deviation and Corresponding Midline Shift on the x-Axis for Each Facial Type[a]

	Midline shift (mm)		
Chin deviation (°)	NGP	HGP	VGP
1	1.09	1.01	1.32
2	2.18	2.02	2.63
3	3.28	3.02	3.95
4	4.37	4.03	5.26
5	5.45	5.04	6.57
6	6.54	6.04	7.88
Lower facial height (Sn-Me') (mm)	62.58	57.78	75.41

[a] HGP indicates horizontal growth pattern; NGP, normal growth pattern; VGP, vertical growth pattern.

After 4° of deviation, VGP and NGP scores did not show any significant differences for all evaluator groups whereas in HGP, the decrease between 4° and 6° was significant for orthodontists and laypeople (Table 2, 3, and 4).

There were no significant differences in ratings in the laypeople and dentist groups between males and females. However, male orthodontists gave significantly lower scores than females in N1 ($P = .039$), L0 and L1 ($P = .007$), H0 ($P = .015$), and H1 ($P = .027$).

DISCUSSION

Measures of human body symmetry are known to correlate with attractiveness, are preferable during mate selection in a variety of animals, and may serve as a sign of genetic quality. Ratings of facial attractiveness improve when symmetry increases.[17] In the literature, presence of a skeletal anomaly is known to decrease patient concerns about asymmetry. In Class I malocclusion patients, 42% were aware of asymmetry, while the remaining sample solely focused on the dentition.[7] This information raises the question, "Do different vertical skeletal patterns have an effect on facial asymmetry?". Numerous studies have evaluated asymmetry in samples that were not differentiated by skeletal patterns. Therefore, the current study aimed to investigate whether variations in vertical pattern had an impact on perception of symmetry and to determine diagnostic threshold levels for chin asymmetry among orthodontists, dentists, and laypeople.

Treatment of facial asymmetry primarily aims to correct an underlying issue, such as malocclusion, through orthognathic surgery. At the end of treatment, dentofacial and occlusal harmony can be achieved. Sometimes, surgical procedures also may be required. In light of this, patient and clinician views regarding facial structures

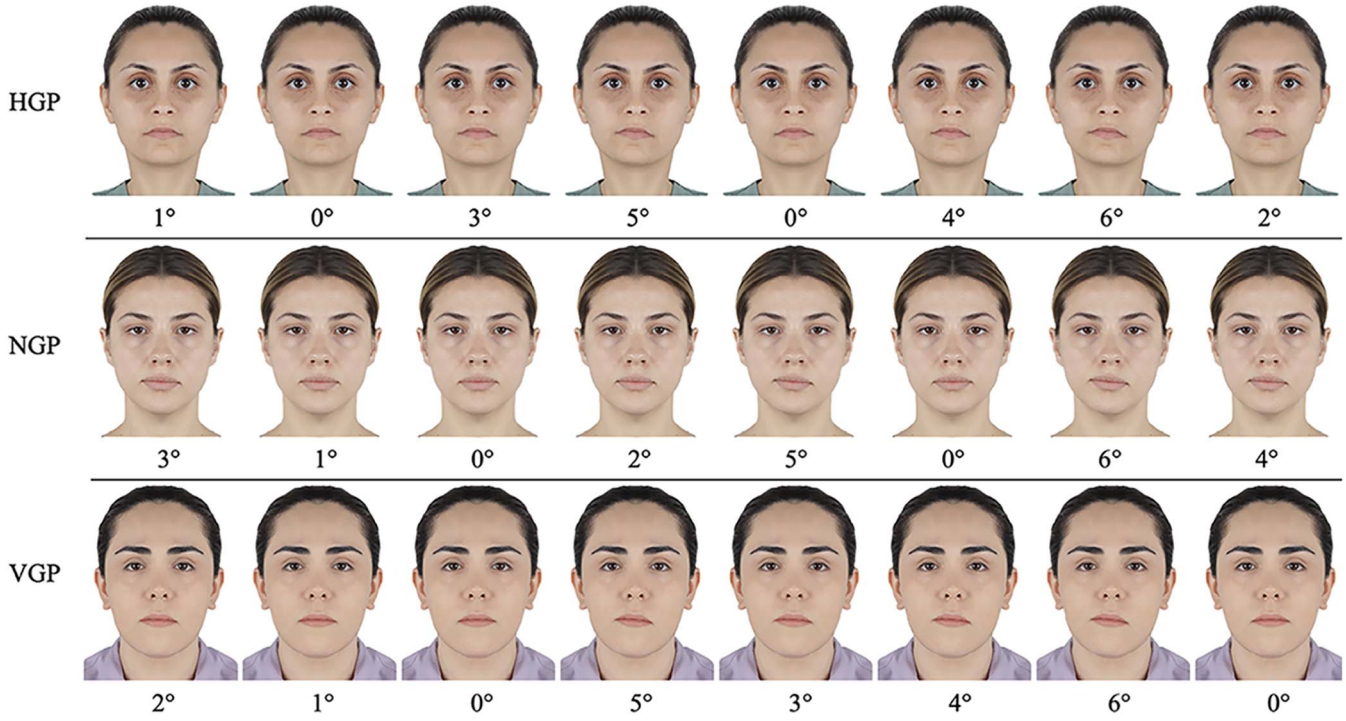

Figure 2. Altered images of each model with random order. HGP indicates horizontal growth pattern; NGP, normal growth pattern; VGP, vertical growth pattern.

play a decisive role in treatment planning.[2] When comparing the evaluator groups, dentists are representatives of primary oral healthcare and, thus, they have an important role in initial diagnosis. However, the desires of laypeople (as potential patients) direct treatment goals under the orthodontist's guidance, whose opinion will serve as a benchmark.

Individuals with naturally different vertical patterns were preferred as models in this study, due to statements in previous research that digital manipulation patterns of photographs can easily be detected by evaluators in digitally altered images, leading a biased perception.[18] During digital alteration of images, possible distractions were eliminated by mirror imaging facial halves and retouching skin irregularities. Throughout photographic alteration of the lower face, left-sided deviation (to the patient's right side) was determined from the viewer's perspective. Facial attractiveness perception was reported to be more greatly influenced by stimulus from the left side of the face.[19] This situation, called "*left gaze bias,*" is an automatic reflection of hemispheric lateralization in face processing of the human brain.[20] To avoid bias,

Table 2. Intragroup and Pairwise Score Comparisons for Normal Growth Pattern (NGP)[l,m]

	Orthodontists (n = 75)			Dentists (n = 73)			Laypeople (n = 78)		
Designation	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
N0	8.17^{a}	1.81		6.98^{e}	2.09		6.97^{i}	2.38	
N1	7.64^{ab}	2.08		6.46^{ef}	1.95		6.46^{ij}	2.52	
N2	6.76^{bc}	2.03		5.58^{fg}	1.96		6.06^{ij}	2.4	
N3	5.45^{c}	2.01	0*	4.86^{g}	1.97	0*	5.10^{j}	2.27	0*
N4	3.70^{d}	2.07		3.41^{h}	2.17		3.50^{k}	2.14	
N5	3.38^{d}	2.09		3.04^{h}	1.91		3.41^{k}	2.18	
N6	2.37^{d}	1.97		2.36^{h}	1.96		2.76^{k}	2.38	

* $P < .05$.

[l] "N" indicates normal growth pattern. Numbers indicate degrees of rotation ranging from 0 to 6°.

[m] Superscript letters (a–k) after the values represent pairwise comparisons within each group. Different letters mean statistically significant differences.

Table 3. Intragroup and Pairwise Score Comparisons for Horizontal Growth Pattern (HGP)[n,o]

	Orthodontists (n = 75)			Dentists (n = 73)			Laypeople (n = 78)		
Designation	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
H0	6.40^{a}	2.29		5.50^{f}	2.44		5.37^{j}	2.68	
H1	6.18^{a}	1.97		5.43^{f}	2.5		5.33^{j}	2.59	
H2	5.14^{ab}	2.34		4.43^{fg}	2.21		4.69^{jk}	2.57	
H3	4.14^{bc}	1.85	0*	3.67^{gh}	1.87	0*	3.66^{kl}	2.04	0*
H4	3.41^{cd}	2.16		3.06^{hi}	1.82		3.21^{l}	2.01	
H5	2.66^{de}	1.84		2.45^{i}	1.84		2.73^{lm}	2.1	
H6	1.93^{e}	1.71		2.02^{i}	1.99		2.05^{m}	1.97	

* $P < .05$.

[n] "H" indicates horizontal growth pattern. Numbers indicate degrees of rotation ranging from 0 to 6°.

[o] Superscript letters (a–m) after the values represent pairwise comparisons within each group. Different letters mean statistically significant differences.

Table 4. Intragroup and Pairwise Score Comparisons for Vertical Growth Pattern (VGP)[k,l]

	Orthodontists (n = 75)			Dentists (n = 73)			Laypeople (n = 78)		
Designation	Mean	SD	*P*	Mean	SD	*P*	Mean	SD	*P*
V0	6.42[a]	2.4		5.34[d]	2.35		5.60[g]	2.66	
V1	6.20[a]	2.31		5.24[d]	2.33		5.12[g]	2.65	
V2	5.54[a]	1.85		4.69[d]	2.21		4.57[gh]	2.37	
V3	3.96[b]	1.81	0*	3.05[e]	1.69	0*	3.4 [hi]	2.13	0*
V4	3.10[bc]	1.85		2.76[ef]	1.82		2.94[ij]	2.09	
V5	2.81[bc]	2.05		2.36[ef]	1.75		2.70[ij]	2.21	
V6	1.96[c]	1.84		1.82[f]	1.61		2.07[j]	2.02	

* $P < .05$.

[k] "V" indicates Vertical growth pattern. Numbers indicate degrees of rotation ranging from 0 to 6°.

[l] Superscript letters (a–j) after the values represent pairwise comparisons within each group. Different letters mean statistically significant differences.

images of each model were shown on different pages, raters were instructed to score each model separately in terms of esthetics without pointing out any region of interest or goal of the study. Additionally, the visual analog scale used for each image is a scoring tool that is commonly used in studies evaluating facial esthetics.[21]

In the literature, there is no consensus on whether the age of evaluators has an impact on their assessments[22] and no significant age difference was found between evaluator groups in the current study. While some studies stated that evaluator gender did not influence the level of perception of esthetics,[23,24] Cross and Cross claimed that men were stricter raters when rating females.[25] Similarly, in the current study, male orthodontists scored the most symmetric images (N1, L0, L1, H0, H1) significantly lower than females.

Based on the current results, vertical facial patterns were found to affect perception of symmetry. Slight asymmetry, often referred to as "relative symmetry", "subclinical asymmetry", or "normal asymmetry", usually goes unnoticed by its possessors and observers.[3] Padwa et al. suggested that an occlusal plane cant of 4° was the threshold for recognition by 90% of observers.[26] In the current study, deviations under 3° in VGP and HGP were not recognized by any evaluator group while, in NGP, dentists and orthodontists could detect slighter deviations (2°). Severt and Proffit reported that asymmetric individuals usually complained about other accompanying skeletal deviations.[7] The difference between perception of NGP and other groups may have been due to more deviant vertical characteristics in HGP and VGP compared to a barely visible chin deviation.

When evaluating chin deviation in millimetric distances, the first detectable amounts of deviation are shown in Table 5. According to trigonometric calculations, linear deviation amount increased for the same degree of deviation as vertical dimension elongated. Regarding this increase, it might be thought that a slight chin deviation would be more apparent in a long face, yet the lowest perception sensitivity with the highest threshold was, surprisingly, in VGP for all evaluator groups (3.95 mm). The value decreased to 2.18 mm for dentists and orthodontists, and to 3.28 mm for laypeople when scoring NGP. In HGP, the value was 3.02 mm for all evaluators (Table 5). These results were similar to previous studies, which stated that thresholds for recognizing asymmetry ranged between 4 and 5.6 mm when evaluated by laypeople,[14,15,27] and between 2 and 4 mm[14,16] for orthodontists. These findings were also consistent with Naini et al., which stated that detection of asymmetry up to 5 mm was not easy.[28] Nonetheless, growing involvement with social media and concurrently increasing esthetic demands might be the cause of the decrease in mean rating scores as chin deviation increased.

Saguntео et al. found that the mean values of deviation requiring treatment were 7.39 mm to the right and 6.92 mm to the left.[16] Dong et al. investigated recommendations for the need for surgical intervention and found that threshold values were 8 mm for orthodontists and dentists, compared to 10 mm for laypeople.[14]

Previous studies have found that more severe asymmetries have a more detrimental impact on facial esthetics.[3] In the current study, severe deviations (4-6°) were distinguished more acutely in HGP by orthodontists ($P = .017$) and laypeople ($P = .044$). However, no significant difference was found in VGP and NGP after 4° of deviation. During digital editing, the mandible was bodily rotated to maintain realistic facial features, causing a rotated lip, different vertical levels of mandibular borders, and differences between bilateral gonial angles and levels. These

Table 5. Threshold Levels for Recognizing Chin Deviation[a]

	Laypeople			Dentists			Orthodontists		
	Threshold			Threshold			Threshold		
	(°)	(mm)	*P* Value	(°)	(mm)	*P* Value	(°)	(mm)	*P* Value
NGP	3	3.28	.001*	2	2.18	.032*	2	2.18	.037*
HGP	3	3.02	.008*	3	3.02	.001*	3	3.02	.00*
VGP	3	3.95	.00*	3	3.95	.00*	3	3.95	.00*

* $P < .05$.

[a] HGP indicates horizontal growth pattern; NGP, normal growth pattern; VGP, vertical growth pattern.

changes might have distracted raters, therefore leading to unexpected results. However, surgical correction of occlusal canting by rotating the maxilla and mandible resulted in simultaneous improvement of lip symmetry, demonstrating how soft tissues follow skeletal corrections.[29]

It was noteworthy that all 6° altered images had the lowest rating regardless of evaluator group, whereas 0° images were scored highest by orthodontists as expected, due to their proficiency. In contrast, Jarosz et al. reported that orthodontists were the most critical raters, followed by dentists and laypeople. Nonetheless, diagnosis sensitivity in increments of asymmetry was almost at the same level for orthodontists and dentists, regardless of their level of scoring. In a study by Sagunteo et al., orthodontists were also reported as the most sensitive for identifying deviation, followed by orthodontic candidates, laypeople, and orthodontic patients.[16]

The limitations of this study included not being able to evaluate asymmetry on stereophotogrammetic data since asymmetry may be present in three dimensions. However, 2D photography was deemed sufficient for the purpose of the study given that frontal evaluation is the easiest way to assess facial asymmetry.[30] Since the questionnaire was carried out online, it may be assumed that participants using devices with different screen sizes may have affected standardization of the assessment. Additionally, altering the whole lower face contributed to a more realistic looking result; however, rotation of the entire mandibular body and lips may have distracted perception from the chin region. Future studies should consider defining the cause of unesthetic appearance with the help of eye-tracking devices. This could help to better define points or regions that observers are focused on more precisely.

CONCLUSIONS

- Vertical growth pattern has a significant influence on perception of lower facial asymmetry.
- In NGP, orthodontists and dentists can recognize slighter deviations (2°).
- The diagnostic threshold for chin deviations was 3° for VGP and HGP by all evaluator groups.
- In severe degrees of deviation, increments of asymmetry can be perceived more in HGP by orthodontists and laypeople.
- In VGP and NGP, there was no significant difference after 4° of deviation.
- Diagnostic sensitivity for increments of asymmetry was at similar levels for orthodontists and dentists.
- Orthodontists gave the highest scores when rating symmetrical images.
- Images with the greatest chin deviation (6°) had the lowest ratings, regardless of evaluator group or vertical pattern.

ACKNOWLEDGMENTS

The authors have nothing to declare.

REFERENCES

1. Lindauer SJ. Asymmetries: diagnosis and treatment. *Semin Orthod*. 1998;4:133.
2. Cheong YW, Lo LJ. Facial asymmetry: etiology, evaluation, and management. *Chang Gung Med J*. 2011;34:341–351.
3. Thiesen G, Gribel BF, Freitas MPM. Facial asymmetry: a current review. *Dental Press J Orthod*. 2015;20:110–125.
4. Agrawal A, Bagga DK, Agrawal P, Bhutani RK. An evaluation of panoramic radiograph to assess mandibular asymmetry as compared to posteroanterior cephalogram. *APOS Trends Orthod*. 2015;5:197–201.
5. Bailey LJ, Proffit WR, White R Jr. Assessment of patients for orthognathic surgery. *Semin Orthod*. 1999;5:209–222.
6. Lee GC, Yoo JK, Kim SH, Moon CH. Lip line changes in Class III facial asymmetry patients after orthodontic camouflage treatment, one-jaw surgery, and two-jaw surgery: a preliminary study. *Angle Orthod* 2017;87:239–245.
7. Severt TR, Proffit WR. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. *Int J Adult Orthodon Orthognath Surg*. 1997;12:171–176.
8. Lum V, Goonewardene MS, Mian A, Eastwood P. Three-dimensional assessment of facial asymmetry using dense correspondence, symmetry, and midline analysis. *Am J Orthod Dentofacial Orthop*. 2020;158:134–146.
9. Chew MT. Soft and hard tissue changes after bimaxillary surgery in Chinese Class III patients. *Angle Orthod* 2005; 75:959–963.
10. Proffit WR, Turvey TA. Dentofacial asymmetry. In: Proffit WR, White RP, eds. *Surgical Orthodontic Treatment.* St. Louis, U.S.: Mosby; 1991:574–644.
11. Haraguchi S, Iguchi Y, Takada K. Asymmetry of the face in orthodontic patients. *Angle Orthod* 2008;78:421–426.
12. Alhammadi MS, Halboub E, Al-Mashraqi AA, et al. Perception of facial, dental, and smile esthetics by dental students. *J Esthet Restor Dent*. 2018;30:415–426.
13. Jarosz KF, Bosio JA, Bloomstein R, Jiang SS, Vakharia NS, Cangialosi TJ. Perceptions of chin asymmetries among dental professionals and laypersons. *Am J Orthod Dentofacial Orthop*. 2018;154:201–212.
14. Dong T, Ye N, Yuan L, Wu S, Xia L, Fang B. Assessing the influence of chin asymmetry on perceived facial esthetics with 3-dimensional images. *J Oral Maxillofac Surg*. 2020; 78:1389–1396.
15. McAvinchey G, Maxim F, Nix B, Djordjevic J, Linklater R, Landini G. The perception of facial asymmetry using 3-dimensional simulated images. *Angle Orthod* 2014;84: 957–965.
16. Sagunteo P, Verayangkura P, Nisalak P, Charoenying H. *Frontal Symmetrical Facial Esthetic Perception and Treatment Decisions: the Differences Among Dental Professionals, Orthodontic Patients and Laypeople*. Bangkok, Thailand: Mahidol University; 2006.
17. Perrett DI, Burt DM, Penton-Voak IS, Lee KJ, Rowland DA, Edwards R. Symmetry and human facial attractiveness. *Evol Hum Behav*. 1999;20:295–307.
18. Tolosana R, Rathgeb C, Vera-Rodriguez R, et al. Future trends in digital face manipulation and detection. In: Rathgeb C, Tolosana R, Vera-Rodriguez R, Busch C. *Handbook of*

Digital Face Manipulation and Detection: From DeepFakes to Morphing Attacks. Cham, Switzerland: Springer International Publishing; 2022:463–482.
19. Burt DM, Perrett DI. Perceptual asymmetries in judgements of facial attractiveness, age, gender, speech and expression. *Neuropsychologia*. 1997;35:685–693.
20. Guo K, Smith C, Powell K, Nicholls K. Consistent left gaze bias in processing different facial cues. *Psychol Res*. 2012; 76:263–269.
21. Tatarunaite E, Playle R, Hood K, Shaw W, Richmond S. Facial attractiveness: a longitudinal study. *Am J Orthod Dentofacial Orthop*. 2005;127:676–682.
22. Tobiasen JM. Social judgments of facial deformity. *Cleft Palate J*. 1987;24:323–327.
23. Chang CA, Fields HW Jr, Beck FM, et al. Smile esthetics from patients' perspectives for faces of varying attractiveness. *Am J Orthod Dentofacial Orthop*. 2011;140:e171–e180.
24. Cochrane SM, Cunningham SJ, Hunt NP. Perceptions of facial appearance by orthodontists and the general public. *J Clin Orthod*. 1997;31:164–168.
25. Cross JF, Cross J. Age, sex, race, and the perception of facial beauty. *Dev Psychol*. 1971;5:433–439.
26. Padwa BL, Kaiser MO, Kaban LB. Occlusal cant in the frontal plane as a reflection of facial asymmetry. *J Oral Maxillofac Surg*. 1997;55:811–816.
27. Liao YF, Chen YF, Yao CF, Chen YA, Chen YR. Long-term outcomes of bimaxillary surgery for treatment of asymmetric skeletal class III deformity using surgery-first approach. *Clin Oral Investig*. 2019;23:1685–1693.
28. Naini FB, Donaldson AN, McDonald F, Cobourne MT. Assessing the influence of chin prominence on perceived attractiveness in the orthognathic patient, clinician and layperson. *Int J Oral Maxillofac Surg*. 2012;41: 839–846.
29. Aoyama I, Oikawa T, Nakaoka K, Sekiya T, Hamada Y, Nakamura Y. Lip morphology in patients with facial asymmetry can be corrected by 2-jaw surgery. *J Oral Maxillofac Surg*. 2018;76:2404–2410.
30. Zachrisson BU. Orthodontic treatment in a group of elderly adults. *World J Orthod*. 2000;1:55–70.