Three-dimensional Evaluation of Facial Harmony in Orthodontic Patients with Vertical Growth Pattern

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Abstract

Aim: **To three-dimensionally evaluate the facial harmony in orthodontic patients with vertical growth pattern.** *Materials and Methods:* **Cone-beam computed tomography (CT) scans were obtained in 10 normal occlusion adults (4 men, 6 women) with vertical growth pattern, and reconstructed into 3-dimensional (3D) models by using a 3D image software. 3D position of 12 hard tissue landmarks, 3 midlines and 9 pairs of bilateral landmarks, were identified in 3D coordination system, and their right and left differences were calculated and analyzed.** *Results:* **The right and left difference values derived from the study indicated a degree of facial asymmetry in the vertical growers. The lateral ramal inclination was the most asymmetric value.** *Conclusions:* **A degree of facial asymmetry exists in the vertical growers. The lateral ramal inclination is a significant parameter in the assessment of facial asymmetry in the vertical growers. Facial asymmetry tends to increase according to the lower and lateral positioning of the landmarks in the face. There is a tendency towards left-side dominance.**

Keywords: Cone-beam computed tomography, facial asymmetry

Introduction

Facial asymmetry is one of the characteristic traits used to assess facial beauty and attractiveness[1]. The human face is bilaterally symmetrical, divided into right and left halves. However, it was found that there is always a degree of deviation from this perfect symmetry. That's why a perfectly symmetrical face doesn't always correlate to a beautiful face[2]. In light of this, it must be emphasized that facial asymmetry is a common finding[3-5]. Many radiographic imaging techniques have been used to assess the facial asymmetry such as the submentovertex technique[6,7], the poster anterior cephalograms[8,9] and the panoramic radiography[10,11]. However, these two-dimensional imaging methods have many shortcomings; magnification, distortion and projection errors. Variation in skull rotation during submentovertex projection affects both linear and angular measurements significantly[12,13]. Also, projection errors influence the angular measurements in postero-anterior cephalometry[14]. According to several electronic databases, vertical measurements taken from conventional or digital panoramic im

ages are still not true representations of the real objects they correspond to due to magnification errors[15]. With the recent advances in the 3D radiographic modalities, facial asymmetry could be evaluated with greater accuracy and reproducibility[16-18]. Data of previous studies revealed great variability of the two-dimensional radiographic methods from the gold standard, while they found that the three-dimensional evaluation was much more precise[19]. Furthermore, three-dimensional computed tomography was used to assess the topography of facial asymmetry and it was found to be a practical method of evaluating the morphology of facial asymmetry[20,21]. Studies showed that three-dimensional soft tissue analysis provided information about vertical skeletal parameters, which allowed assessment of vertical craniofacial morphology[22]. The patient's growth pattern influences the skeletal, dental, soft tissue components of the face, as well as the facial profile. Since, these components are contributing to facial asymmetry, assessment of facial asymmetry in patients with different vertical growth patterns is an essential part of diagnosis. The purpose of the present study was to use the cone-beam computed tomography in the evaluation of facial asymmetry in patients with vertical growth pattern.

Materials and Methods

The subjects of this study were selected from patients seeking orthodontic treatment at the Orthodontic Clinic, Faculty of Dentistry, Suez Canal University. The selected sample included 10 patients,6 females (mean age 20.5 years) and 4 males (mean age 20.9 years), with the following criteria (Age range from 18 years to 25 years, full complement of permanent teeth (excluding third molars), no previous orthodontic/ orthopedic/orthognathic surgical treatment, no history of trauma and no obvious gross facial asymmetry). For each selected patient, a lateral cephalogram to determine the type of growth was taken using cephalometric machine Orthophox under the following conditions 90 KV,12 mA, CCD CEPH 23,00 x 0.65 cm. During x-ray projection, the patient is standing in an upright position with a relaxed facial expression and the Frankfurt Horizontal plane is parallel to the floor. Cone beam computed tomography was used to assess the facial asymmetry. The computed tomography scans were obtained using SCANORA cone beam CT imaging device under the following conditions 90 KV,10 mA [Fig 2 (a) and (b)], voxel size 0.5mm x 0.3 mm, field of view (FOV) (H x D) 240x165 mm. The image data produced are in digital imaging and communication in medicine (DICOM) format. The *OnDemand3D* software version is used to reconstruct the axial images into a 3D model. During 3D scanning, the patient is seated in an upright position and the midsagittal plane is perpendicular to the floor. The cephalometric radiographs of the patients were traced and analyzed to determine the type of patient's growth. The following cephalometric angular measurements were recorded: Sum of posterior angles (Bjork angle)= SNAr + SArGo + ArGoMe, Y-axis, Facial axis angle, Gonial angle, Upper gonial angle, and Lower gonial angle. The type of the growth pattern for each patient was determined based on the following cephalometric readings[23]. To evaluate the facial asymmetry, the following 3D landmarks were identified on the 3D CT images by using the *OnDemand3DApp. 1.0.9.2469. The parameters used to assess facial asymmetry included*[24]: *1.Maxillary Height:* First molar to Fran-

Table 1: Parameters used to assess the patient's growth pattern

	Methods for Predicting Growth Direction		
Parameter	Range	Variation	Type of Growth
Sum of Posterior angles (Bjork)	396°± 6	<390	Horizontal
		>402	Vertical
Y-axis	61°± 6	<55	Horizontal
		>67	Vertical
Facial axis angle (Ricketts)	87°± 7	<80	Horizontal
		>94	Vertical
Gonial angle	124°±5	>129	Vertical
		<119	Horizontal
Upper Gonial angle	52°±3	>55	Horizontal
Lower Gonial angle	70°±5	>75	Vertical

kfurt Horizontal (Po-Or-Po)–distance between the Frankfurt Horizontal (FH) plane and the occlusal fossa of the maxillary first molar (in mm) 2. *Mandibular Height:* Canine to mandibular plane (Ag-Me-Ag), distance from the canine cuspal tip perpendicular to the mandibular plane (in mm). *3.Ramus Length:* Condylion superior–Gonion inferior–distance between the highest point of the condyle and the lowest point of the gonion area (in mm). *4.Mandibular Body Length:* Menton–Gonion posterior, distance between menton and the most posterior point of the gonion area (in mm). *5.Frontal Ramal Inclination:* Condylion lateral–Gonion lateral to midsagittal reference plane (Op-Cg-ANS)–angle formed by the FH plane and the posterior border of the ramus (in degrees). *6.Lateral Ramal Inclination:* Condylion

posterior–Gonion posterior to FH (Po-Or- Po), angle formed by the FH plane and the posterior border of the ramus (in degrees). The right and left sides of the face for every patient were compared to determine the degree of facial asymmetry. All the data were tabulated and analyzed using the Statistical Package of Social Science Software program, version 21 (SPSS).

Results

The means and standard deviations of each parameter of facial asymmetry and of the right and left differences of the landmarks in every patient are presented in table 3 and figures (1 and 2). The lateral ramal inclination

Table 2: Parameters used to assess the facial asymmetry

Landmark	Abbreviation	Description
1. Crista galli	Cg	Most superior point of crista galli of ethmoid bone.
2. Opisthion	Op	Most post. point on post. margin of foramen magnum.
3. Porion	Po	Highest point on roof of external auditory meatus.
4. Orbitale	Or	Deepest point on infraorbital margin
5. Condylion superius	Cd sup	Most superior point of condyle head
6. Condylion lateralis	Cd lat	Most lateral point of condyle head
7. Condylion posterius	Cd post	Most posterior point of condyle head
8. Gonion lateralis	Go lat	Most lateral point of gonion area
9. Gonion posterius	Go post	Most posterior point of gonion area
10. Gonion inferius	Go inf	Most inferior point of gonion area
11. Antegonion	Ag	Deepest point of antegonial notch of mandible
12. Menton	Me	Most inferior point on mandibular symphysis

was found to be the most asymmetric value, followed by the ramus length. The mandibular height was the least asymmetric value. The left side measurements of the face were higher than the right-side measurements re

garding the maxillary height, the mandibular body length, the frontal ramal inclination and the lateral ramal inclination. The right-side measurements were higher for the mandibular height and the ramus length.

Table 3: Description of each parameter for the group of Vertical Growers

	Vertical growers								
	Range		Mean	±	SD	Median	IQR		
RT Maxillary Height	42.6	- 53.9	46.0	±	3.4	46.2	42.7	-	46.4
LT Maxillary Height	44.3	- 52.7	47.2	±	2.8	46.2	45.1	-	48.9
RT Mandibular Height	35.4	- 45.9	40.1	±	3.6	38.8	37.5	-	42.7
LT Mandibular Height	35.4	- 46.4	39.5	±	4.2	38.2	35.7	-	43.4
RT Ramus Length	50.7	- 78.7	61.3	±	9.5	59.1	52.8	-	69.8
LT Ramus Length	48.5	- 72.1	58.6	±	7.6	55.4	54.9	-	64.6
RT Mandibular body length	104.0	- 134.4	119.5	±	9.4	117.3	114.2	-	123.8
LT Mandibular body length	107.7	- 137.1	119.7	±	9.5	117.4	112.5	-	124.4
RT Frontal Ramal Inclination	67.5	- 86.0	79.1	±	5.1	80.5	76.5	-	82.5
LT Frontal Ramal Inclination	70.0	- 86.5	81.0	±	5.3	81.5	80.0	-	85.5
RT Lateral Ramal inclination	72.0	- 85.5	77.5	±	4.7	76.8	73.5	-	81.0
LT Lateral Ramal inclination	77.5	- 88.5	83.0	±	3.4	82.0	81.0	-	86.0
Maxillary Height Differences	0.4	- 7.4	2.2	±	2.0	1.8	0.9	-	2.5
Mandibular Height Difference	0.0	- 2.1	1.0	±	0.9	0.6	0.3	-	2.1
Ramus Length Differences	0.3	- 6.6	3.5	±	2.0	4.0	2.9	-	4.3
Mandibular body length Diff.	0.1	- 4.7	2.1	±	1.7	2.2	0.3	-	3.7
Frontal Ramal Inclination Diff.	0.0	- 9.0	2.9	±	2.7	2.3	1.0	-	3.5
Lateral Ramal inclination Diff.	0.0	- 9.5	5.5	±	3.4	6.3	3.0	-	8.5

SD= standard deviation, IQR= interquartile range (Range from 25th–75th percentiles)
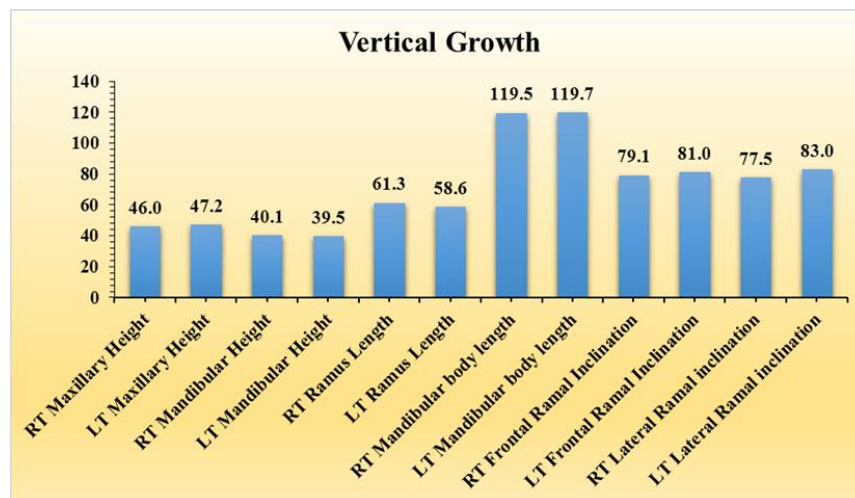

Figure 1: Histogram showing the measured values for each parameter on each side for the vertical grower.
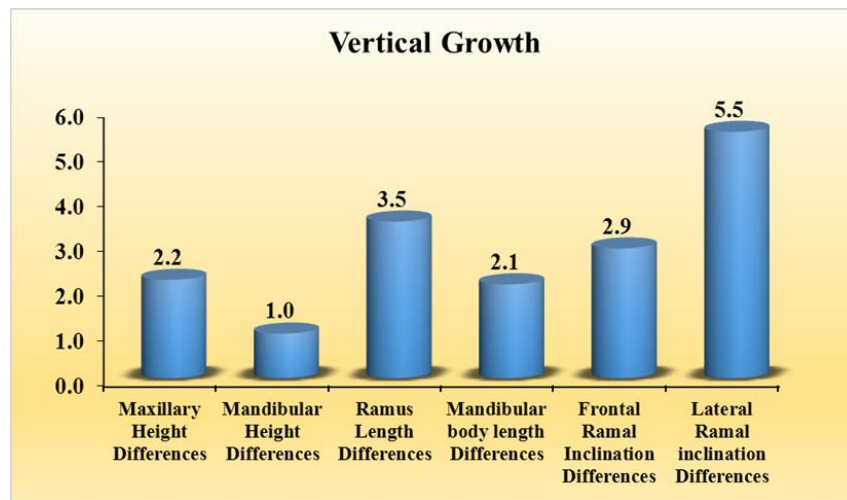
Figure 2: Histogram showing the means differences of facial asymmetry parameters for the vertical growers.

Discussion

Many previous studies have evaluated the facial asymmetry using 2D and 3D imaging techniques. However, there weren't enough studies, assessing the facial asymmetry in patients with vertical growth pattern. In the present study, cone beam computed tomography was used to assess the facial asymmetry in patients with vertical growth pattern. The introduction of 3D imaging methods , such as CBCT ,has reduced the errors of magnification and distortion as well as the projection errors of the 2D imaging techniques. This was confirmed by previous studies[18,22,25,26]. In the present study, four linear measurements in millimeters and two angular measurements in degrees were used to measure the facial asymmetry. These measurements are the same used by Dharmesh et al[17] for the assessment of facial asymmetry. According to the means and standard deviations of the right and left difference of facial asymmetry parameters of the subjects, it was found that a degree of facial asymmetry exists in the vertical growers. This result agreed with other studies[3-5,27]. Lateral

ramal inclination was found to be the most asymmetric value, followed by the ramus length in the vertical growers' group. This suggests that asymmetry increases with the lower positioning and the lateral positioning of landmarks. The current results agreed with other studies[2,4,28,29]. This finding also was confirmed by Hwang et al[30], who demonstrated that the degree of facial asymmetry tended to increase with the lower and lateral positioning of landmarks. However, the present study disagreed with the study carried by Frakas and Cheung[31], who found that the most asymmetric part of the face (69.2%) was the upper third . This may be attributed to the fact that these authors carried out their study on normal Caucasian children and used anthropometrics to evaluate the facial asymmetry. Also, the current results are found to be in disagreement with Ferrario et al[32]. The latter author showed that there was a certain degree of soft tissue facial asymmetry both in individuals and in global populations and that this was especially evident in the middle (tragus) and not only in the lower (gonion) thirds of

the face. These findings may be due to the different ethnic group used in the study. Moreover, Ercan et al[33], showed that the most asymmetric part of the face in both sexes was the middle third of the face. In the previous study, the facial landmark data were collected from two-dimensional digital images of 321 young healthy subjects. This could explain why these findings were different from the results of the present study. The present results disagreed with some of the findings of Dhermash et al[17], who revealed that the mandibular body length was the most asymmetric value obtained by using the conventional radiographic images . This might be attributed to the use of additional two-dimensional radiographic method in the latter study and to the different ethnic group. Laterality of asymmetries is defined as differences between the dimensions of the left and right halves of the face. The current results confirmed that there was a left-side dominance. These results were in accordance with some studies[28,34,35]. However, the present results disagreed with others studies[4,17,31,36], that found a slight tendency toward right-side dominance . In the study carried by Peck et al[36] ,they used a different technique in the assessment of the facial asymmetry , which was the postero-anterior cephalometry and a different ethnic group.

Conclusions

The study concludes that: i) A degree of facial asymmetry was detected in the vertical growers. ii) The lateral ramal inclination was found to be a significant parameter in the assessment of facial asymmetry in patients with vertical growth pattern. Iii) This study confirmed the previous studies findings that facial asymmetry increased with the lower and lateral positioning of landmarks. Iv) The left side measurements of the face were found to be greater than the right side.

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