Original Article

Prevalence of facial asymmetry in Tirupati population: A posteroanterior cephalometric and photographic study

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Abstract

Aims and Objective: The human face is the most prominent aspect in human social interactions, and therefore, it seems reasonable opting for orthodontic treatment is to overcome psychosocial difficulties relating to facial and dental appearance and enhance the quality of life in doing so. **Materials and Methods:** Posteroanterior cephalograms and frontal photographs of 100 participants (50 males and 50 females) were analyzed to evaluate skeletal asymmetry by the analysis suggested by Grummons. Soft tissue facial asymmetry was analyzed by composite photographic analysis. The data were statistically analyzed using the Statistical Package for the Social Sciences version 16.0 software. Independent t-test was used to find the differences between different measurements. **Results:** All participants showed mild asymmetry and right-sided laterality. The difference between the right and left sides were statistically insignificant ($P > 0.01$). The test revealed that only Co distance was statistically significant ($P < 0.01$), and all the other values are not statistically significant. **Conclusion:** Composite photographs of hundred participants revealed that facedness is towards the right, however, this laterality was not statistically significant. Both posteroanterior cephalograms and composite photographs showed right-sided laterality. Gender difference in both skeletal and soft tissue asymmetry is not statistically significant.

Key words: *Composite photographs, facial asymmetry, frontal photographs, Grummon's analysis, photographic evaluation, posteroanterior cephalometry*

INTRODUCTION

From early times, human beauty has puzzled mankind for its variety and peculiarities. It has been argued that the degree of asymmetry in bilateral features is one of the fundamental factors underlying human attractiveness.[1]

Many Epidemiological studies pertaining to facial asymmetry have been conducted across the globe. One such study was done by Goel *et al*.[2] to detect the asymmetries and their correlation with malocclusions in Karnataka population. They concluded that there was decrease in magnitude of the asymmetry as higher

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regions of craniofacial skeleton was approached. Studies conducted by Profitt and Severt[3,4] assessing facial asymmetries in orthodontic patients clinically found a prevalence ranging from 12% to 37% in North Carolina, United States, 23% in Belgium, and 21% in Hong Kong. Radiographic examinations reveal values higher than 50%.[5]

Mossey *et al*.[6] performed a similar study to evaluate the size and shape-related craniofacial skeletal asymmetries, and concluded wider left side of the face and a shorter vertical dimension on the right side. Kowner in a classic experiment on the perception of attractiveness based on symmetry conducted in Japan concluded that limited asymmetry may be simply more aesthetic, regardless of its function.[7] Fong *et al*. in a study conducted in Taiwan concluded that 68% of the study population showed chin deviation to the left side and (32%) to the right side.[8]

In another study, Anistoroaei *et al*. concluded that facial asymmetry was present in 4.7% of patients; they also concluded that a significant correlation was evidenced between facial asymmetry and type of malocclusions, age, and type of dentition.[9]

While most of the studies have concluded that no quantitative differences in different types of measurements of face exists in relation to face,[10,11] some studies, such as the one conducted by Ercan *et al*., concluded that the number of significantly asymmetric linear distances between the two halves of the face was greater in females than that in males.[12] Cheng in his review concluded the symmetry of the face is highly influenced by soft tissue landmarks.[13]

The purpose of the present study was to evaluate the prevalence of skeletal facial asymmetry using frontal cephalograms and frontal photographs among the adults of Tirupati, Andhra Pradesh, hitherto assessing the correlation of skeletal facial asymmetry and soft tissue facial asymmetry as well as to assess the gender differences in the prevalence of facial asymmetry.

MATERIALS AND METHODS

A total of 100 residents (50 males and 50 females) of Tirupati, Andhra Pradesh in the age group of 18–25 years were selected for the study through randomized sampling [Tables 1 and 2]. Before commencement of the study, a written informed consent was taken from all the participants of the study. Ethical approval was obtained from the ethical committee. The study was planned and done over a period of 3 months.

The inclusion criteria were clinically acceptable facial symmetry, presence of full complement of teeth, no history of pathology/trauma/surgical intervention or orthodontic treatment, and no congenital abnormalities in the maxillofacial region.

The sample size was calculated using the following formula: $E=Z_{\alpha/2}\ \sigma/\sqrt{n}$

Facial photographs were taken with a Canon Power Shot A 650 IS camera and by the same photographer. Participants were made to stand and assume natural head position, so that their Frankfurt horizontal (FH) planes will be parallel to the floor. The cephalograms were taken in the posteroanterior projection.

The analysis for assessment of transverse frontal facial asymmetry was done by using frontal asymmetry analysis suggested by Grummons [Figure 1].[1] For subjective evaluation, frontal photographs were assessed by using composite photographs.[2,3]

Mid sagittal reference

This is a vertical reference line. According to Grummons, mid sagittal reference (MSR) closely follows visual plane formed by subnasale and the midpoint between the eyes and eyebrows, and hence MSR was selected as the key reference line [Figures 2 and 3].

Horizontal planes

Four planes were drawn to show the degree of parallelism and symmetry of the facial structures. Three planes connected the medial aspects of the zygomatic frontal sutures (ZZ), the centers of the zygomatic arches (ZA), and the medial aspects of the jugal processes (J). Another plane was drawn at menton parallel to the Z plane [Figure 4].

Table 1: Sample size and mean age group of the sample

Total sample	Age range	Males	Females
100	18-25 years	50	50

Table 2: Mean age group of the study groups

Total sample	Sex	Mean age	SD
50	Males	20.92 years	2.3 years
50	Females	20.92 yesrs	1.9 years

Mandibular morphology

Two triangles (right and left) were formed by joining the AG, Me, and Co points on both sides, representing the mandibular morphology. The linear measurements for all the three sides of the triangles were recorded along with the measurements of the angles formed by joining Co, Go, and Me points on both sides [Figure 5].

Linear asymmetry (transverse)

The vertical offset as well as the linear distance was measured from MSR to Co, NC, J, Ag, Go, and Me were measured. The linear distance to MSR from the land marks Co, Nc, J, Ag, Go, U, L, and Me was calculated for paired structures, the distance away from the midline was determined for both landmarks, and the difference between the distances was calculated. For unpaired points, the horizontal distance to the midline will be determined [Figure 6].

Frontal photographs of the participants were taken and each photograph is divided into left and right sides and left half of the face and its mirror image are joined together and similarly right half of the face and its mirror image were joined to form two facial composites, i.e., L-L (left composite) and R-R (right composite). Facedness of the sample or population refers to the side with highest total prevalence [Figure 7].

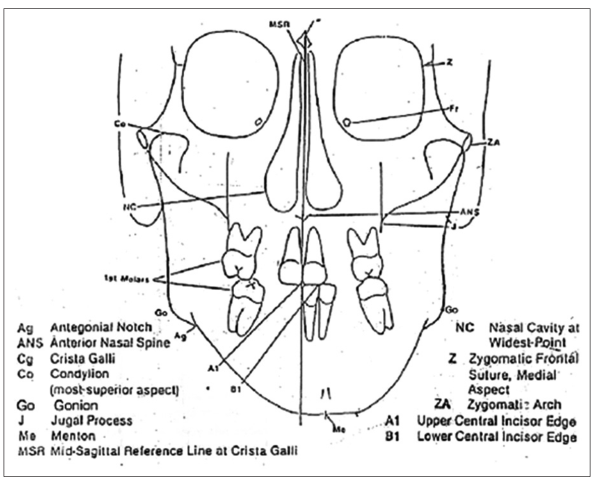

Figure 1: List of Land marks used in this study

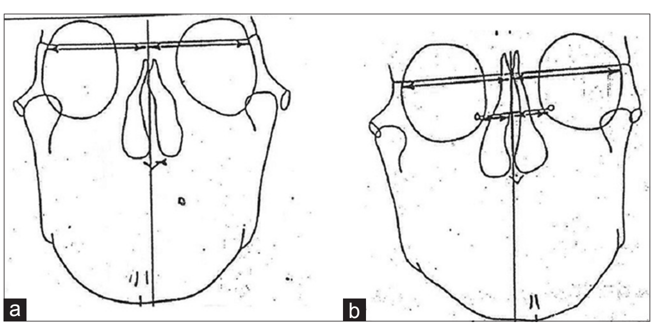

Figure 3: Alternate methods of constructing. (a) Line from midpoint of Z plane through ANS, (b) Line from midpoint of Z plane through Fr-Fr line

RESULTS

The data were statistically collected and tabulated in Microsoft excel. The data was stastically analyzed using the Statistical Package for the Social Sciences (SPSS) version 16.0 program statistical analysis package software. Independent *t*-test was used to find the differences between different measurements and the significance in the measurements of the right and left side dimensions, if any. The data was checked for the normal distribution using *t*-statistics and then the correlation coefficients between the various parameters were calculated using Pearson's correlation to determine which would produce a higher value.

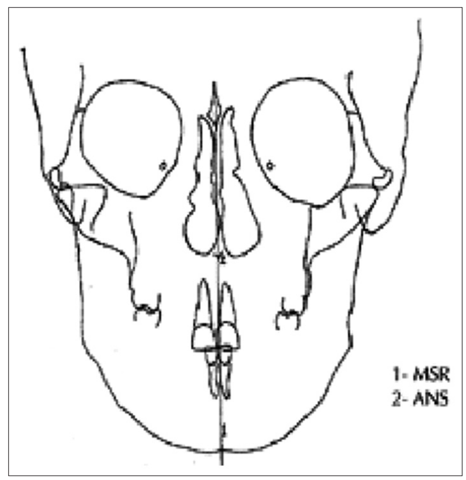

Figure 2: Midsagital reference line

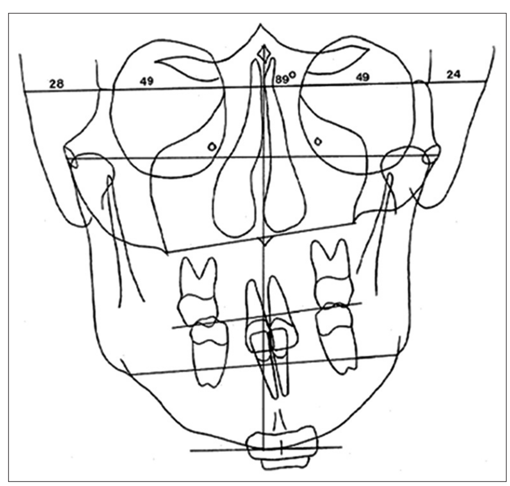

Figure 4: Horizontal plane

Linear asymmetries (transverse)

Table 3 shows the bilateral facial widths observed at Z, Co, Za, J, Nc, Ag, Go distances, as total widths, right side, and left side. Table 4 shows total bilateral facial widths observed at Z, Co, Za, J, Nc, Ag, and Go for males. Table 5 shows total bilateral facial widths observed at Z, Co, Za, J, Nc, Ag, and Go for females.

The results showed statistically significant difference between the mean Z, Co, Za, J, Nc, Ag, and Go values of males and females ($P < 0.01$). The difference between the right and left sides were statistically

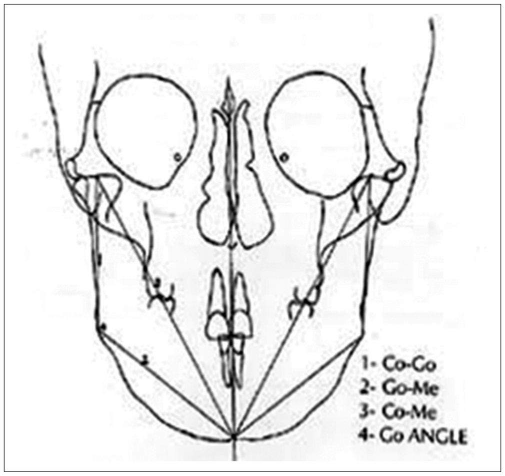

Figure 5: Mandibular morphology

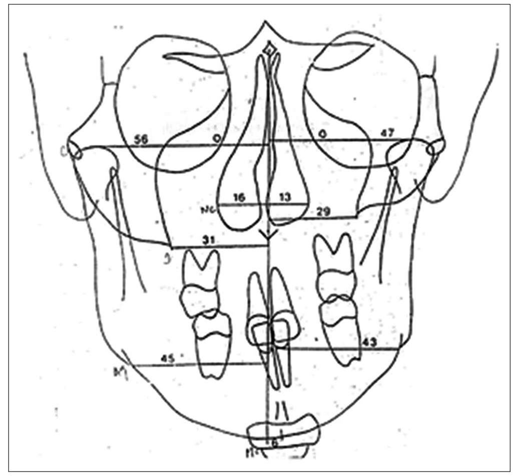

Figure 6: Linear asymmetries

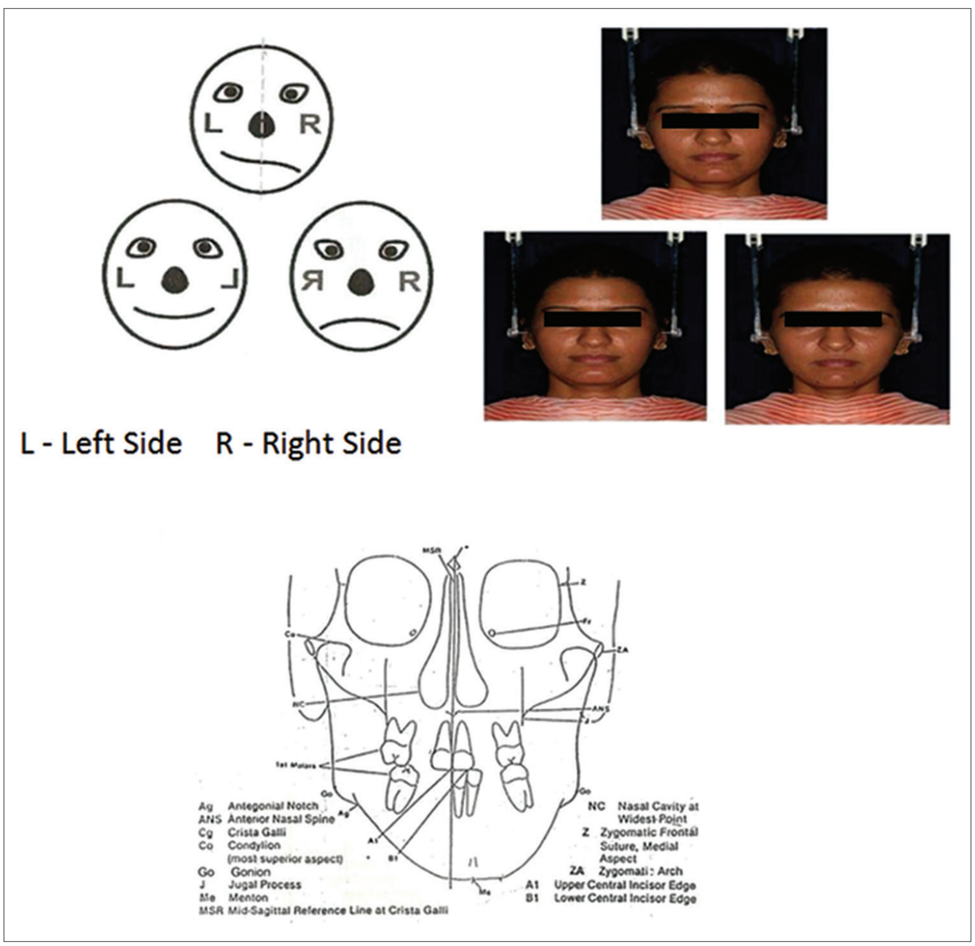

Figure 7: Composite photographs

insignificant ($P > 0.01$). The test revealed that only Co distance was statistically significant ($P < 0.01$). The means and standard deviation of vertical distances from the right and left Z, Co, Za, J, Nc, Ag, and Go to the MSR on both groups are shown in Table 6. No significant difference was observed between males and females ($P > 0.01$).

Table 3: Bilateral facial widths observed at Z, Co, Za, J, Nc, Ag, and Go distance as total width, right side, and left side

	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
'Z' distance	47.257	2.25	47.129	2.166	0.144	0.676
'Co' distance	59.173	3.60	57.708	3.62	2.88	0.004**
'Za' distance	66.78	3.3	66.74	3.9	0.081	0.7
'Nc' distance	16.41	1.52	16.31	1.51	0.412	0.68
'J' distance	32.98	1.81	33.01	1.96	0.13	0.897
'Ag' distance	44.05	2.8	43.64	3.1	0.9	0.34
'Go' distance	46.72	2.65	45.81	2.81	0.862	0.429

**$P \leq 0.01$ *highly significant*

Table 4: Bilateral facial widths observed at Z. Co, Za, J, Nc, Ag, and Go for males

Parameters	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
Z	47.81	2.31	47.69	2.07	0.273	0.785
Co	59.77	3.08	57.025	3.6	−2.625	0.010*
Za	68.26	3.3	68.24	3.1	0.031	0.975
Nc	16.68	1.38	16.49	1.36	−0.691	0.491
J	33.27	1.8	33.65	1.9	0.74	0.461
Ag	45.01	3.1	44.57	2.7	0.732	0.466
Go	47.63	3.1	46.57	2.7	0.862	0.429

*$P \leq 0.01$

Table 5: Bilateral facial widths observed at Z. Co, Za, J, Nc, Ag, and Go for females

Parameters	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
Z	46.69	2.2	46.55	2.07	0.331	0.741
Co	56.24	3.9	54.27	3.0	-2.110	0.035**
Za	65.26	2.7	65.18	2.7	0.0	1.000
Nc	16.11	1.6	16.07	1.5	0.09	0.922
J	32.46	1.9	32.64	1.9	-0.469	0.64
Ag	43.07	2.6	42.81	2.9	0.463	0.644
Go	45.06	2.6	45.16	2.9	0.463	0.64

**$P \leq 0.01$ *highly significant*

Tables 6-8 shows bilateral widths of Co-Go, Go-Me, Co-Me, and gonial Angle to assess the mandibular morphology ($P < 0.05$). There was statistically significant difference between the mean Co-Me value and gonial angle of the right and left sides.

Table 9 shows the Bilateral widths and gonial angle to assess the mandibular morphology in females. The results were statstiscally significant for the coronoid and menton distance and the coronoid gonion and menton distance.

Table 10 shows mandibular offset at menton. Menton deviated to the left side in 55% (2.6 ± 1.4 mm) and deviated to right in 3% (1.6 ± 0.28 mm). In 58% males, there was deviation towards left (2.8 ± 1.6). Whereas towards the right in 2% (1.5 mm). In 52% females, deviation was towards left (2.4 ± 1.02) and towards right 4% (1.7 ± 0.3 mm). The difference between males and females is statistically insignificant ($P > 0.01$).

Table 11 shows parallelism of facial structures. Mean angles formed by Z, Za, J, Me, and occlusal planes with MSR shows that there was no statistically significant canting. The difference between males and females was statistically insignificant.

Tables 12 and 13 show the sidedness of the face by subjective evaluation of composite photographs of 100 participants. Out of a total of 100 participants, it was observed that 81 were right faced (R-R) and 19 were left faced. Thirty-nine males were observed to be right faced (R-R) and 11 were observed to be left faced (L-L). Whereas in females, 42 were observed as right faced (R-R) and 8 were observed to be left faced (L-L). Therefore, in males and females, facedness is towards the right, and female faces were more right faced than males ($P > 0.01$).

Table 6: Vertical offset of Z. Co, Za, J, Nc, Ag, and Go

	Males			Females			*t*	*P*
	Total No	Mean	SD	Total No	Mean	SD		
'Z' distance	1	1		1				
'Co' distance	34	3.18	1.62	32	2.28	1.47	2.18	0.032
'Za' distance	33	2.9	1.3	25	3.2	1.5	0.631	0.531
'Nc' distance	16	1.93	0.854	19	1.097	0.25	0.673	0.506
'J' distance	31	3.66	7.71	24	2.865	1.219	0.999	0.322
'Ag' distance	26	2.8	1.9	27	3.2	1.8	0.717	0.476
Go' distance	26	2.8	1.926	27				

Table 7: Total bilateral widths and gonial angle to assess the mandibular morphology

	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
Co-Go	66.87	6.0	66.12	5.7	0.88	0.37
Go-Me	58.32	5.7	58.21	4.0	0.2	0.81
Co-Me	105.001	5.6	103.79	5.7	2.62	0.09*
Gonial angle	123.67	4.5	121.99	5.9	3.557	0.003**

*$P \leq 0.01$, **$P \leq 0.01$ highly significant*

Table 8: Bilateral widths and gonial angle to assess the mandibular morphology in males

	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
Co-Go	67.42	4.6	66.12	7.8	0.47	0.504
Go-Me	58.84	3.9	58.12	4.4	0.88	0.37
Co-Me	108.58	5.2	106.33	5.6	2.06	0.042*
Co-Go-Me	122.98	4.7	119.48	6.4	3.1	0.003**

*$P \leq 0.01$), **($P \leq 0.01$) highly significant*

Table 9: Bilateral widths and gonial angle to assess the mandibular morphology in females

	Right		Left		*t*	*P*
	Mean	SD	Mean	SD		
Co-Go	61.02	7.8	59.24	4	1.025	0.263
Go-Me	58.80	3.18	58.30	3.6	0.957	0.34
Co-Me	103.24	5.08	101.22	4.54	2.113	0.037*
Co-Go-Me	124.36	4.3	121.34	5.11	3.62	0.002**

*$P \leq 0.01$, **($P \leq 0.01$) highly significant*

Table 10: Mandibular offset at menton

Me	Left			Right		
	No	Mean	SD	No	Mean	SD
Total	55	2.6	1.42	3	1.6	0.28
Males	29	2.8	1.6	1	1.5	-
Females	26	2.4	1.02	2	1.7	0.3

Table 11: Parallelism of facial structures

	Mean	SD
'Z' plane Z-MSR	89.863	0.94
'Za' plane Za-MSR	89.76	0.62
'J' plane J-MSR	89.78	0.71
Plane at Me Me-MSR	90.09	0.7
Occlusal plane MSR-OCC	89.0	1.2

Table 12: Composite photographic analysis – sideness of face

Total	Right Faced	Left Faced	Faced Ness
100	81	19	Right

Table 13: Composite photographic analysis in males and females

Sex	R-R	L-L
M	39	11
F	42	8

DISCUSSION

Asymmetries in the human craniofacial skeleton are a rule rather than exception. This has been verified and stressed upon by many researchers dating back from Shah and Joshi[14] and Peck *et al.*[15]

A posteronterior cephalometric radiographic study of 100 participants with pleasing symmetrical faces and normal occlusions was conducted with the objective of evaluating the extent of facial asymmetry. Frontal photographs were obtained and studied for subjective evaluation of facial asymmetry seen in the selected Tirupati population.

The frontal analysis suggested by Grummons was used to assess the patients for the transverse (skeletal) facial asymmetries as it provides clinically relevant information regarding specific locations and amounts of facial asymmetry and measures mandibular morphology, which can be seen to play a major role in asymmetries.

The results of the present study [Table 1] showed that the bilateral total widths of Z, Co, Nc, Ag, and Co on the right side was greater than those on the left side, however, the difference was statistically insignificant except for Co. Only the Co distance was statistically significant ($P < 0.01$). This shows that asymmetry was present more in the condylar region and towards right side. Similar findings were reported by Farkas and Cheung.[4] The difference between the right and left side mean absolute asymmetry for Z, Nc, abd J distances are less than those for Co, Ag, and Go. These are in agreement with findings of Letzer and Kronman[16] and Peck *et al.*[15]

None of the studies on facial asymmetry measured vertical offsets. In the present study, vertical offsets of Z. Co, Za, J, Nc, Ag, and Go were also measured and no statistical difference between males and females ($P > 0.01$).

For the assessment of the mandibular morphology, Co-Ag, CO-Me, and Ag-Me and gonial angle were statistically analyzed [Table 2]. Gonial angle ($P < 0.001$) showed statistically significant value at 1% level length. The possible cause of asymmetry in gonial angle are asymmetry functional patterns such as unilateral chewing patterns, muscular atrophies, etc., as suggested by Shah and Joshi.[14] It shows that gonial angle is the only region where the right side is larger than the left side.

Mandibular length (Co-Me) and Gonial angle (Co-Go, Me) showed statistically significant difference between the right and left sides, with right side being larger in total as well as in males and females. This is in accordance with a similar study conducted by Shah and Joshi[14] and Azevedo *et al*.[17]

Chin deviations in our study showed a left sidedness, which is in agreement with findings of Severt and profit.[3] The high incidence of chin deviation may be due to the asymmetries of mandibular length, which also showed high incidence. The possible reason given by Woo[18] is the increased size of the right hemisphere of brain. The right side dominance in brain affects the functional activities and facial structures.

The mean values obtained for the angles formed by the various planes used in this analysis were more or less parallel to each other. These findings are in agreement with Ricketts and Grummons.[19]

In our study on composite photographic analysis, it was observed that 81% shows right sidedness and 19% shows left sidedness. The findings in our study are in concordance with Hardie *et al*.[11] andHaraguchi *et al*.[10]

Mild asymmetry was observed both in males and females with males having wider faces than females. Co distance showed statistically significant right sidedness ($P < 0.01$). Me-Co length showed statistically significant right sidedness in total ($P < 0.01$); males ($P < 0.05$), females ($P < 0.05$).The findings in our study are in concordance with many studies,[2,4,14,18,20,21] however, left side laterality was observed in few studies.[22,23]

Seventy-eight percent of males and 88% females were observed as right faced (R-R) on composite photographic analysis. The difference between males and females was statistically insignificant ($P > 0.01$). The findings in our study are in concordance with those carried out by Farkas and Cheung,[4] and Ferrario Virgilio *et al*.[24] The findings in our study differ with Smith.[25]

According to Kim *et al*.[26] generally, skeletal deviation must be greater than 4 mm to render the asymmetry visible in an individual's face. Therefore, other authors consider an asymmetrical face as having bone deviations equal to or greater than 2 mm. This might be the major drawback of the study because the present study utilized photographs also for determining the depth of facial asymmetries.

Other main limitations of the study are the errors in identifying the anatomical landmarks in posteroanterior cephalograms due to superimposition of many craniofacial structures. A three-dimensional topographic study or cone-beam computed tomography (CBCT) could be used in the future to diagnose facial asymmetries. Complete CBCT software to identify different landmarks three dimensionally could also be helpful in marking the facial asymmetries.[27,28] Other advanced means such as the use of stereophotogrammetry,[29] (three-dimensional photography) or quantifying facial soft tissue asymmetry by a three-dimensional imaging-based method,[30-32] or use of the Weibull distribution-based comparison of a person's asymmetry with respect to a large sample of symmetrical faces[27,33,34] would be more accurate.

SUMMARY AND CONCLUSIONS

All participants showed mild skeletal asymmetry on posteroanterior cephalograms which was not statistically significant. Composite photographs of hundred participants revealed that facedness is towards right, however, this laterality was not statistically significant. Both posteroanterior cephalograms and composite photographs showed right-sided laterality. Gender difference in both skeletal and soft tissue asymmetry was not statistically significant.

In the evaluation for an orthodontic treatment, asymmetry of the face should be considered and may only be noticed with a morphometric analysis. The present data may be of use for future clinical studies, but studies with larger sample at different geographical locations are warranted. A classification for asymmetry based on the data collected for the Asian group would be useful for future research on this subject.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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