Skeletal asymmetry in esthetically pleasing faces

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Within the innate system of human values, symmetry and balance in nature are easily recognized and appreciated. Symmetry and balance, when applied specifically to facial morphology, refer to the state of facial equilibrium: the correspondence in size, form and arrangement of facial landmarks on the opposite sides of the median sagittal plane. Although many faces may appear symmetrical and well-balanced on clinical soft tissue examination, cephalometric x-ray studies[1-10] have revealed varying degrees of craniofacial asymmetry as a characteristic of all faces. Using three-cycled Fourier equations to represent the frontal view of the craniofacial skeleton, Lu[11] reported that only facial asymmetries greater than 3% are clinically discernible.

The present study was undertaken to quantify the morphologic intensity and variability of subclinical craniofacial asymmetry in a selected group of subjects recognized subjectively for qualities of facial esthetics including symmetry and balance.

Materials and methods

The sample consisted of 52 white adult subjects selected solely on the basis of soft tissue facial appearance. Each participant had been previously acclaimed in some manner by a segment of the general population as possessing those qualities of facial esthetics which are the most pleasing. This sample, which was described in earlier published studies,[12,13] included professional models, beauty contest winners, and performing stars noted for their facial attractiveness.

Forty-nine of the subjects were female and three subjects were male. The ages ranged from 15 years 9 months, to 46 years 8 months. The subjects' mean age was 21 years 2 months. From a cursory examination of occlusion, Angle Class I molar relationships of varying degrees were observed in all 52 participants.

Each subject was positioned in a Margolis cephalostat for standardized x-ray and photographic records. A posteroanterior (PA) cephalogram was obtained with each subject in centric occlusion.

Abstract

An x-ray cephalographic method was used to analyze 52 exceptionally well-balanced white adult faces for skeletal asymmetry in the posteroanterior (PA) projection. Three frontal facial lines were constructed using bilateral skeletal landmarks: laterosuperior orbit (LO), lateral zygoma (Zyg), and gonion (Go). All subjects demonstrated measurable asymmetries. Data showed less asymmetry and more dimensional stability as the cranium is approached. A slight tendency toward right-side dominance was not statistically significant.

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Key Words

Facial asymmetry • Face • Cephalometry • Esthetics

Table 1
Bilateral facial width: total, left side, and right side (in millimeters), N=52

Skeletal Dimension	Total Bilateral Width $\bar{X}$	SD	Left Side $\bar{X}$	SD	Right Side $\bar{X}$	SD
Laterosuperior orbit (LO)	104.2	4.8	52.0	2.4	52.2	2.6
Lateral zygoma (Zyg)	139.5	6.3	69.4	3.6	70.1	3.4
Gonion (Go)	99.4	6.7	49.4	4.5	50.0	3.5

Figure 1

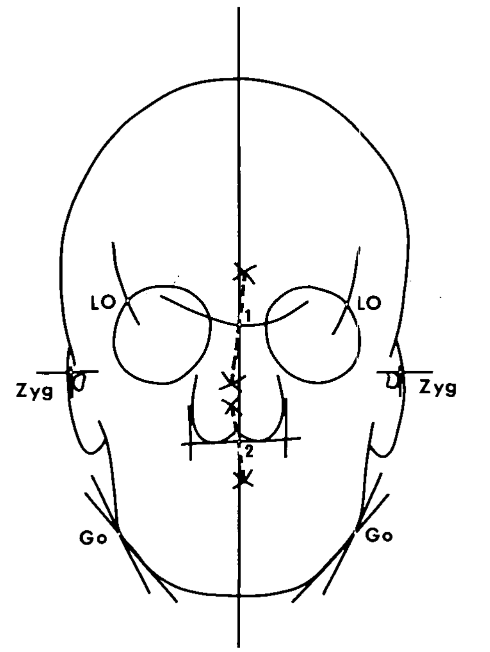

Figure 1
Cephalographic tracing showing construction of midskeletofacial reference line through points 1 and 2. Bilateral craniofacial landmarks utilized in asymmetry analysis are: laterosuperior orbit, LO; lateral zygoma, Zyg; and gonion, Go.

A midskeletofacial reference line was then constructed on each cephalogram. There is no consensus regarding the selection of landmarks to represent the midfacial plane on the PA projection.[14-16] Many landmarks such as crista galli or anterior nasal spine are difficult or impossible to identify accurately on adult PA cephalograms. A method proposed by Shore[17] using easily discernible landmarks to construct two midface points was employed to generate a midfacial reference line, as shown in Figure 1. Point 1 is defined as the point of bisection between the medial aspects of the orbits at the level of the planum sphenoid. Point 2 is determined from the anatomic structure of the nose: projections of lines tangent to the lateral borders of the nasal wall and perpendicular to the horizontal axis of the cephalostat were made. These two projections were intersected by a line drawn tangent to the most inferior point of each of the nasal cavities. The distance between the intersections was bisected to form point 2.

Determinations of skeletal asymmetry were computed from three bilateral landmarks as defined by Sassouni:[16] (1) laterosuperior orbit, LO; (2) lateral zygoma, Zyg; and (3) gonion, Go.

Data were accumulated in the following manner: the distance between each landmark, left and right, and the midskeletofacial line was recorded in millimeters. The difference between each pair of measurements was also recorded in millimeters as left side minus right side; in this way sidedness in facial asymmetry could be evaluated. The total width between the bilateral landmarks (the sum of the left and right sides) was calculated.

The absolute value of the left-right differences was used to compute the mean absolute asymmetry for each of the three dimensions studied.

In addition, the degree of variability for each dimension was examined by calculating the root mean square (RMS) asymmetry. Separate computations were made to test for left side or right side dominance within the sample. Sidedness for each subject was indicated with a positive (+) sign for the left side and a negative (-) sign for the right side.

The error of the method was determined by randomly selecting a sample of eight PA cephalograms for retracing. The 48 new measurements were compared with the earlier values. The mean double-determination error was 0.6 mm.

Results

Each of the 52 subjects demonstrated asymmetries in one or more of the dimensions measured (Figure 2). Table 1 reports the bilateral facial widths measured in millimeters at LO, Zyg, and Go, as total width, left side and right side.

Table 2 shows the mean absolute asymmetry for the three bilateral craniofacial dimensions investigated. The LO data showed the least asymmetry: the mean absolute asymmetry ($\bar{X}_{|d|}$) or the mean absolute difference between left and right sides was 0.87 mm. The Zyg data showed a mean absolute asymmetry of 2.25 mm. The Go data exhibited the most asymmetry with a

Left-Right differences (mm)

Subject number	Craniofacial landmarks LO	Zyg	Go
7	0	-3	-9
12	-1	+3	+8
42	-1	-9	-12
1	0	-1	0
35	0	0	+1
49	0	0	+1

Figure 2

Figure 2
Extremes of skeletofacial asymmetry among esthetically pleasing subjects (N=52). Subjects 7, 12 and 42 demonstrated the greatest measurable asymmetries and subjects 1, 35 and 49 showed the smallest measurable asymmetries. The smiling frontal photographs of these six subjects are hardly revealing of the underlying left-right differences, confirming the subclinical nature of these discrepancies.

mean absolute value of 3.54 mm.

The root mean square (RMS) asymmetry (Table 2) for each of the three measured variables corresponded closely to the standard deviation of the signed left-right difference, because the mean differences were close to zero. Therefore, RMS and SD can be used interchangeably as measures of variability in this special case.

In the evaluation of side dominance or sidedness, the mean asymmetries for all three dimensions demonstrated slight right side bias (Table 2). A paired *t*-test was performed for each variable to determine the significance of this facial skew to the right. None of the left-right side differences was statistically significant. Therefore, in this sample there was no reportable sidedness for the three frontal craniofacial dimensions measured; the slight right side bias was attributable to random variation only.

Correlation coefficients (Pearson's r) were calculated among the three dimensions measured using a one-tailed test based upon the expectation of small subclinical asymmetries. The associations among the three signed craniofacial dimensions were:

LO : Zyg $r = 0.31$, $p < 0.025$
LO : Go $r = 0.00$, n.s.
Zyg : Go $r = 0.59$, $p < 0.001$

Discussion

In this study, the mean absolute asymmetry data provide indices of subclinical asymmetry for a sample possessing clinical symmetry and balance. The mean absolute asymmetry recorded at the level of the laterosuperior orbit was less than one-half that observed at lateral zygoma and less than one-fourth the asymmetry at gonion.

A more meaningful index of asymmetry is the standard deviation (SD) of the mean left-right difference or, in this special case, the root mean square (RMS) asymmetry, both of which are expressions of metric variability. The laterosuperior orbit dimension demonstrated an SD and RMS asymmetry on the order of one-half and one-third of the variabilities at lateral zygoma and gonion, respectively, in this study.

The data suggest that the craniofacial complex exhibits less asymmetry and greater dimensional stability as the cranium is approached. These results tend to validate the use of the laterosuperior-orbital roentgenographic landmark as a cranial reference point on the PA cephalogram.

Studies[8,15,18] have shown the PA film to have some inherent limitations of methodology and reliability. The submental vertex (SMV) view has been suggested[19,20] as a better alternative for the cephalometric assessment of asymmetry; however, the SMV view is capable of significant distortion,[7,8] especially in the analysis of mandibular asymmetry, since the mandible is positioned farthest from the film plane. While still useful in comparative research studies of asymmetry, both PA and SMV roentgenograms may have limited value in orthodontic diagnosis and treatment planning for the individual. Three-dimensional radiography by either computed tomographic (CT) scans[21] or the digitized inte-

Table 2
Skeletofacial asymmetry: mean absolute values, variability, and sidedness (in millimeters), N=52

	Absolute values		Variability	Sidedness		
Dimension	$\overline{X}_{\lvert d \rvert}$	$Range_{\lvert d \rvert}$	RMS asymmetry	$\overline{X}_d$	SD	t^a
LO	0.87	0-4	1.22	-0.14	1.22	0.80[b]
Zyg	2.25	0-9	3.00	-0.64	2.96	1.55[b]
Go	3.54	0-12	4.44	-0.65	4.43	1.06[b]

d = difference, left side minus right side
[a] = paired *t*-test, d.f. = 51
[b] = not significant

gration of sagittal and posteroanterior cephalograms[22] probably offers the most promise today in the analysis of multiplane skeletofacial deformity, including asymmetry.

Regarding sidedness or left-right dominance, this study failed to show statistically significant direction in any of the three dimensions investigated. Shah and Joshi[6] have reported right facial dominance in all the components of their asymmetry analysis. Woo[23] has suggested that right craniofacial dominance may be naturally favored for neuroanatomic developmental reasons. However, other studies[4,5,7,9] have found a tendency toward left-side dominance. Detailed reports on bilateral tooth size asymmetry by Garn, Lewis, and Kerewsky[24,25] have failed to show any statistically significant right-left biases.

Among the well-balanced faces in this sample, the strongest association in symmetry/asymmetry was between Zyg and Go ($r = 0.59$, $p < 0.001$). Since these two dimensions relate anatomically through dental occlusion, tooth position may be a significant developmental determinant of this strong positive correlation.

Conclusions

In this study an attempt was made to quantify subclinical asymmetries in clinically symmetrical faces. From posteroanterior cephalograms of 52 exceptionally well-balanced white adult faces, values were established for mean absolute asymmetry and root mean square asymmetry at the levels of laterosuperior orbit, lateral zygoma and gonion. The laterosuperior orbit exhibited the least asymmetry and the least variability of the three dimensions studied. Additional tests to determine right-left dominance within the data were performed. A slight tendency toward right-side bias was not statistically significant.

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