Asymmetry of the Human Facial Skeleton

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Introduction

Measurements of the craniofacial skeleton, either directly from living subjects, dry skulls or cephalometric radiographs, are commonly used in investigations of growth and development of the face, jaws and dentition.

Woo carried out direct chordal and arcual measurements on a large number of skulls from the 26th to the 30th Egyptian dynasties.[21] He found that the bones of the cranium exhibited an asymmetry with the right side being larger reflecting the development of the right hemisphere of the brain. The contralateral side of the facial complex exhibited an asymmetry with the left zygoma and left maxilla being larger. The lower third of the facial skeleton was not investigated.

Direct measurements of the soft tissue facial form, although inaccurate due to distortion of facial soft tissues, have given much data on facial growth.[10,11]

Indirect methods of measuring skull form have been well-documented.[3,4] The three dimensional appraisal using cephalometric radiographs has been achieved by a few workers. Björk[1] used metallic implants to record fixed points within the facial complex. Mulick investigated facial asymmetry in six like-sex triplets using a three-dimensional grid system.[12]

A method using photogrammetry has been used to investigate certain parameters of facial soft tissue form.[5,14] This method overcomes many of the problems of indirect facial measurement such as posing error and distortion. The technique has been applied to asymmetry of the facial soft tissues by Burke.[6]

Clinicians involved in the fields of oral surgery and orthodontics have for some time sought objective guidelines for the assessment of the range of facial asymmetry in normal children.

The facial complex consists of numerous constituent parts. It is, therefore, the degree of harmony between the parts which determines the symmetry of the whole. This study was devised to establish a method for the analysis of standardised posteroanterior cephalometric radiographs and to investigate facial asymmetry in terms of its components, each of which is capable of individual variation between the right and left sides. By adopting such an approach, it was felt that a systematic diagnostic procedure would evolve, to locate not only the more obvious gross features which are clinically important, but also to shed light on the aetiology and development of the condition.

Method

Sixty-three randomly-selected cephalometric radiographs of normal children referred to an orthodontic clinic were traced. No child with a degree of clinically evident or unacceptable facial asymmetry or gross deviation of dental arrangements was included. The age range of the children was 9-18 years with a mean of 14. The sex distribution was 20 males, 43 females. The tracings were performed by one of the authors. The error of the method was found by double determination.[7]

The anatomical points used are shown in Figure 1. Figure 2 illustrates

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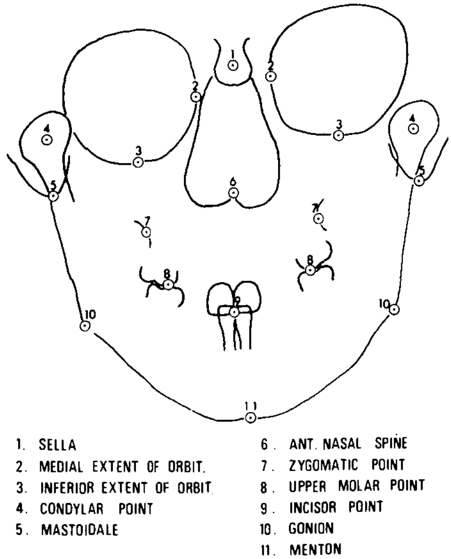

Fig. 1 Roentgenographic landmarks.

the method of construction of the two longitudinal axes representing the midline of the maxillary and mandibular regions. The lines between the bilateral co-ordinates were bisected and the midline points marked. A line of best fit was drawn between the following points to form an axis X which represents the middle third of the face: sella, anterior nasal spine and bisectors of lines joining the medial extent of orbits, right and left orbitale, right and left mastoidale, bilateral zygomatic points, and right and left molar points.

The following points were joined by a line of best fit to form an axis N which represents the lower third of the face: menton and bisectors of lines joining condylar points and bilateral gonial points.

The angle of divergence of the axes is proportional to the degree of asymmetry between the middle and lower third of the face for the individual investigated. This asymmetry becomes more apparent the more remote the point of convergence of the axes is from the centre of the facial complex. The angle between the two axes can be bisected to give the arbitrary anatomical axis of the face, as shown in Figure 3.

To assess the relative asymmetry of the component areas of the facial complex and to study the mechanisms whereby the effect of the asymmetry

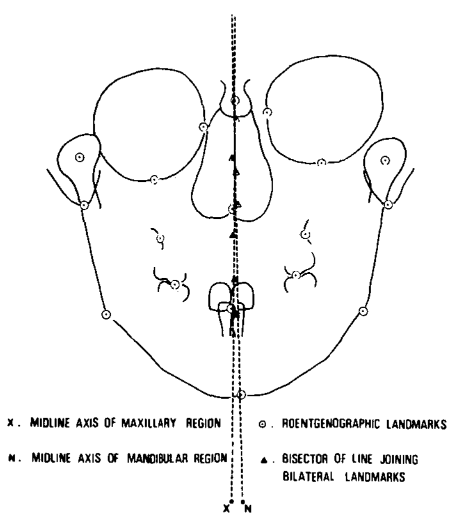

Fig. 2 Asymmetry of the middle and lower third of the face compared.

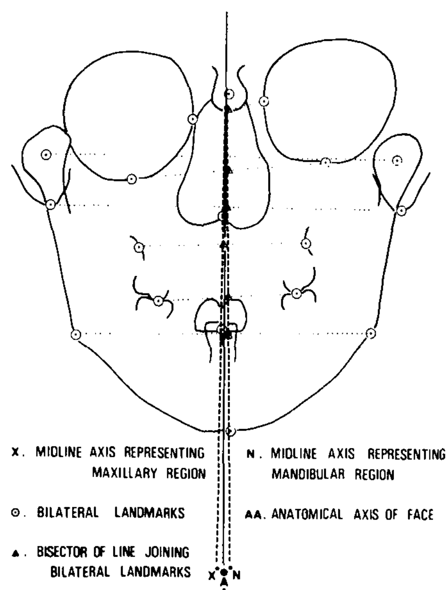

Fig. 3 Method of construction of the arbitrary anatomical axis and longitudinal axes of the middle and lower thirds of the face.

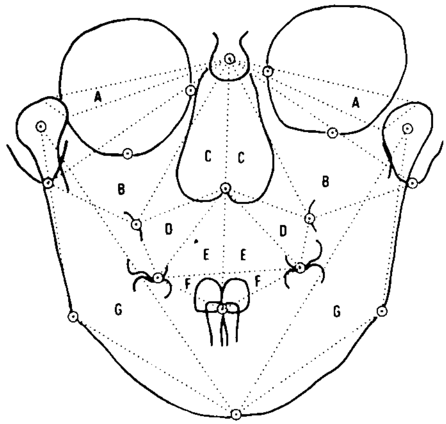

Fig. 4 Triangulation of the face.

is minimised on the integration of the facial structures, a method of triangulation was used.

The reference points already described were plotted and the following triangles (Fig. 4) drawn on both sides of the tracings: A) between the extreme upper extent of the head of the condyle, extreme mesial extent of the head of the condyle and sella to represent the cranial base region; B) between sella, mastoidale and the root of the zygoma representing the lateral maxillary region; C) joining sella, anterior nasal spine and the root of the zygoma representing the upper maxillary region; D) drawn between the root of zygoma, upper molar points and the anterior nasal spine representing the right and left middle maxillary regions; E) joining anterior nasal spine, upper molar points and the point of intersection of a line drawn between the bilateral upper molar points and the arbitrary anatomical axis representing the right and left lower maxillary regions; F) drawn between upper molar points, upper incisal point and the point of intersection of a line joining the upper molar points and the anatomical axis representing the right and left dental regions; G) drawn between the condylar points, gonion, and menton to represent the mandibular component of the face.

The sides of the triangles were measured to the nearest 0.5 mm with a vernier caliper gauge with the standard error determined by Dahlberg's method of double determination. The areas of the respective triangles were calculated for the component areas of the face and the standard error again determined by Dahlberg's method. The mean values of the component areas and the mean differences between the right and left sides of the face, the standard error of the mean differences and paired t test values are given in Table I.

Results

The axis representing the middle third of the face was found to deviate to the left of the axis representing the lower third of the face in 67 per cent of subjects with a mean angle of divergence of 1.9 degrees ($\pm$ 0.25). Table I shows that the cranial base regions and maxillary regions exhibit an overall asymmetry with the larger side being the left. The mandibular and dentoalveolar regions exhibit a greater degree of symmetry.

These findings agree with those of Burke and Mulick who reported from their investigations that the maxillary regions were larger on the left side. There was no vertical correlation of variation of asymmetry.

Discussion

The distribution of asymmetry on the normal body has been well-documented.[9,15-19] The incidence of hypoplasia of the first branchial arch is commoner on the right side[6] and cleft lip is more frequent on the left side.[8]

AREA	MEAN		MEAN DIFFERENCE	STANDARD ERROR MEAN DIFF.	VALUE t (PAIRED T.)	P.
	RIGHT	LEFT				
A	222.67	267.07	-44.41	± 8.62	5.14	<0.01
B	931.60	1020.04	-88.44	±22.22	3.98	<0.01
C	663.85	677.60	-13.75	± 6.78	2.03	<0.05
D	307.98	304.77	3.21	± 6.12	0.52	>0.05
E	260.40	265.08	- 4.68	± 3.38	1.39	>0.05
F	114.46	117.82	- 3.37	± 1.80	1.87	>0.05
G	1401.12	1373.31	27.82	±19.97	1.39	>0.05

DEGREES OF FREEDOM 62.

TABLE I

Distribution of facial asymmetry.

That this investigation has demonstrated an over-all facial asymmetry with the larger side being the left is not surprising, but defies explanation. The findings suggest a compensatory adaptation during growth to effect an integration of the facial components. Scott[20] suggested that the facial skeleton should be considered as a unit built up of a number of semi-independent regions, each with its own pattern of growth and development. The orbits, nasal cavities and lower border of the mandible show a high degree of independence with their size and shape genetically determined. The dento-alveolar region and the lower parts of the nasal cavities show a greater response to functional adaptation. These suggestions may be supported by the present findings.

It is reasonable to assume that optimum masticatory function is provided by maximum cuspal interdigitation of the teeth. This arrangement can be arrived at in occlusion even though facial asymmetry may exist. If in the rest position, or in the habit postural position of the mandible, the upper and lower teeth are not co-incident about the sagittal plane, then an asymmetrical functional activity must compensate during both mastication and the approximation of the dental arches. This may lead to a dysfunction of the temporo-mandibular joint mechanism and is not a normal adaptation in man. To enable bilaterally symmetrical function and maximum intercuspation of teeth to occur, compensatory changes seem to be operating in man in the growth and development of the dento-alveolar structures which minimise the underlying asymmetry in the spatial arrangement and size of the jaws.

It is well-recognised that the lingual and labial musculature mould the dento-alveolar structures. This may possibly reduce underlying asymmetry sufficiently to produce cuspal contacts as the teeth erupt. The further eruption and final occlusal position of the teeth is influenced by cuspal guidance. These factors may therefore compensate for the underlying basal asymmetry.

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References

1. Björk, A. Facial growth in man, as studied with the aid of metallic implants. *Acta Odontol. Scandinav.* 13: 9-34, 1953.
2. Broadbent, B. H. A new x-ray technique and its application to orthodontics. *Angle Orthodont.* 1:45, 1931.
3. ———. The face of the normal child. *Angle Orthodont.* 7:183-208, 1937.
4. Brodie, A. G. Growth pattern of the human head from the third month to the eighth year. *Amer. J. Anat.* 68:209-262, 1941.
5. Burke, P. H. and L. F. Beard. Stereophotogrammetry of the face. *Amer. J. Orthodont.* 53:769-782, 1967.
6. Burke, P. H. Stereophotogrammetric measurement of normal facial asymmetry in children. *Hum. Biol.* 4:536-548, 1971.
7. Dahlberg, G. *Statistical Methods for Medical and Biological Students.* New York Interscience Publication. 1940.
8. Fogh-Andersen, P. *Inheritance of Harelip and Cleft Palate,* Copenhagen, Nyt. Nordisk Forlag, Arnold Busck A.S. 1942.
9. Lundstrom, A. Some asymmetries of the dental arches, jaws and skull and their aetiological significance. *Amer. J. of Orthodont.* 47:81-106. 1961.
10. Micklashveskay, N. N. Growth of the head and face in boys of various ethnic groups in the U.S.S.R. *Hum. Biol.* 38:231-250. 1966.
11. ———. Sex differences in growth of the head and face in children and adolescents. *Hum. Biol.* 41:250-262, 1969.
12. Mulick, J. F. An investigation of cranio-facial asymmetry using the serial twin study method. *Amer. J. Orthodont.* 41:658-678, 1965.
13. Savara, B. S. A method of measuring facial bone growth in three dimensions. *Hum. Biol.* 37:245-255, 1965.
14. Tanner, J. M. and J. S. Weiner. The reliability of the photogrammetric methods in anthropometry. *Amer. J. Phys. Anthrop.* 7:145-186, 1949.
15. Torgersen, J. Familial transposition of viscera. *Acta Med. Scand.* 126: 319-322, 1946.
16. ———. Transposition of viscera, bronchiectasis and nasal polyps. *Acta radiol. Stockh.* 28:17-24, 1947.
17. ———. Anomalies of the spine in anomalies of the viscera and constitution. *Acta Radiol. Stockh.* 29:311-320, 1948.
18. ———. Concordant situs inversus in dizygotic twins. *J. Hered.* 39:293-294, 1948.
19. ———. Genic factors in viscera asymmetry and in the development and pathologic changes of the lungs, heart and abdominal organs. *Archs. Path. Chic.* 47:566-593, 1949.
20. Scott, J. H. The analysis of facial growth in the anterior and vertical dimension. *Amer. J. Orthodont.* 44: 507-513, 1958.
21. Woo, T. L. On the asymmetry of the human skull. *Biometrika.* 22:324-341, 1931.