Dental and Other Bodily Dimensions in Different Orthodontic Categories

C. L. B. Lavelle, Ph.D., M.D.S.

Introduction

Malocclusion is only rarely conditioned by gross anomalies in facial development, for the face with malocclusion is generally well within the range of normal variation although characterised by disharmony of parts.[1] Evidence has been accumulating, however, in favour of the hypothesis that dental arch and skull development is based upon an inheritable growth pattern.[2] Polygenic control is assumed because simple Mendelian models have failed to yield an explanation of genetic mechanisms and because of the known phenotypic plasticity. Nevertheless, the contribution of nongenetic factors has yet to be established in relation to the craniofacial complex, or to even the postcranial skeleton as a whole. The dimensions of the dental arches are mainly affected by genetic factors[3] and, from comparison of identical and like-sexed fraternal twins, genetic factors exert a greater influence on most craniofacial dimensions than nongenetic factors.[4,5] Thus the craniofacial complex appears to be influenced by both genetic and nongenetic factors, although further data are required before it can be established which regions are predominantly affected by genetic factors and which by nongenetic factors.

In addition to various craniofacial dimensions being associated one with another,[6] there may also be correlations between the skull and other bodily dimensions.[7,8] Thus genetic factors possibly influence not only the skull in isolation, but also other skeletal dimensions may be concerned by the same factors. The present study was therefore undertaken to contrast the skull, dental arch, tooth and other bodily dimensions in Class I, Class II and Class III occlusal categories to assess whether only the dental arch and tooth dimensions are affected or whether other skeletal dimensions are involved.

Materials and Methods

Subjects

A total of 300 male British Caucasoid subjects were included in this study. They comprised equal samples from Angle's Class I, II and III occlusal categories defined by the method of Beresford.[9] To simplify this study, Class II, Division 1 and Class II, Division 2 occlusal relationships were grouped together. The skeletal classification was assessed clinically using the method outlined by Ballard[10] into Classes 1, 2 and 3. Again, to simplify the study, the subjects were selected so that the categories of occlusion coincided with the skeletal categories, i.e., Angle Class I with skeletal Class 1, Angle Class II with skeletal Class 2 and Angle Class III with skeletal Class 3.

The subjects were from the age range 16-18 years and, apart from their occlusal and skeletal relationships, were selected on the basis that each had (a) competent lips, (b) complete permanent dentitions (excluding the third molars), (c) no obvious skeletal, facial or dental abnormality, (d) approximately the same somatotype,[11] and (e) no previous history of orthodontic treatment.

Measurements

Using standard anthropological techniques,[12] the following dimensions were measured on each subject:

1. Stature;
2. Skeletal dimensions: a) lengths of

TABLE I

BODILY, SKULL AND ARCH DIMENSIONS OF ANGLE'S CLASS I, II AND III CATEGORIES

	CLASS I		*CLASS II*		*CLASS III*	
	Mean	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*
Stature	1795	5.71	1733	4.95	1804	4.64
Humerous length	345	1.68	349	1.74	340	1.52
Radius length	262	1.27	268	1.18	257	1.03
Tibia length	390	2.19	384	2.05	401	2.24
Ankle width	78	0.34	81	0.28	74	0.39
Knee width	96	0.40	99	0.49	93	0.47
Wrist width	60	0.27	59	0.31	63	0.34
Elbow width	70	0.33	69	0.36	72	0.28
Head length	194.3	0.62	190.7	0.74	195.9	0.64
Head width	159.6	0.48	156.4	0.53	161.3	0.50
Head circumference	586.4	1.24	579.2	1.38	592.6	1.41
Biauricular width	138.4	0.41	137.2	0.51	141.1	0.56
Bicondylar width	137.5	0.52	136.4	0.46	138.8	0.48
Bizygomatic width	141.7	0.47	140.0	0.41	143.5	0.47
Bigonial width	104.9	0.39	101.5	0.35	107.3	0.43
Arch length maxilla	48.2	0.23	49.7	0.20	47.5	0.27
mandible	43.5	0.21	42.6	0.31	44.7	0.36
Arch width maxilla	45.5	0.29	45.8	0.25	44.3	0.38
mandible	39.7	0.27	38.9	0.22	40.8	0.31

S.E. = standard error

humerus, radius and tibia, b) widths of elbow, wrist, knee and ankle;

3. Skull dimensions: a) head length, width and circumference, b) biauricular, bicondylar, bizygomatic and bigonial widths;

4. Arch dimensions: a) width, distance between the centres of the second permanent molar teeth, b) length, minimum distance between the most mesial aspect of the left central incisor to the most distal aspect of the second permanent molar, all dimensions being recorded from casts;

5. Tooth dimensions: mesiodistal and buccolingual crown diameters. These tooth dimensions were measured for the incisors, canines, premolars and first and second molars on the left side of the maxillary and mandibular dental arches. In a few cases the dimensions of isolated teeth on the right rather than the left side of the dental arch were measured due to loss of tooth substance arising from fillings or caries.

As a check on accuracy, all the above dimensions were measured five times by two independent observers on five subjects selected randomly from each category. Any inconsistencies arising from the measurement technique proved statistically insignificant ($P > 0.2$) when compared with the variation existing between different individuals by analysis of variance.

Results

The data obtained from this study revealed conflicting patterns of contrast between the three categories of patients (Table I) depending upon which dimensions are compared (Figs. 1 and 2). For instance, Class II's were 3.5% smaller in stature than Class I subjects, whereas ankle width was 3.8% greater in Class II than Class I individuals. The various skull dimensions were smaller in Class II than

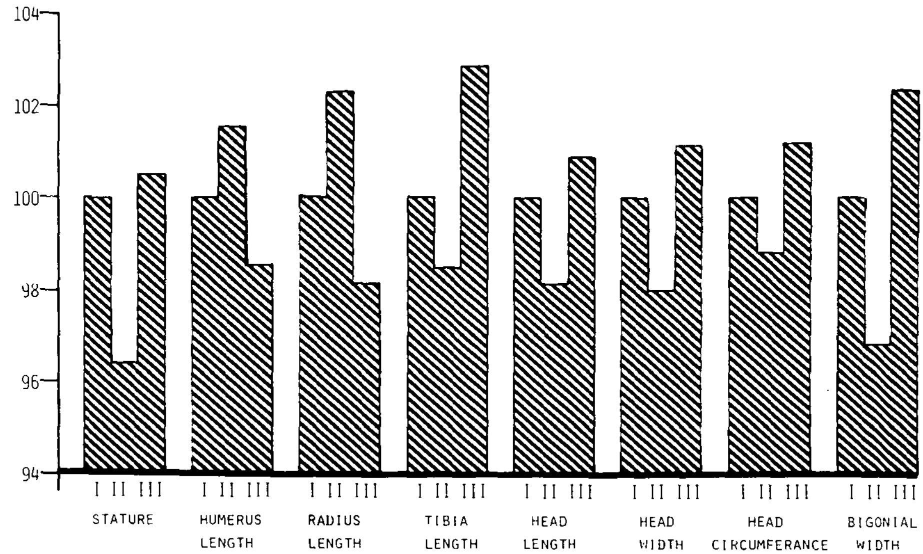

Fig. 1 Mean bodily and skull dimensions in Angle's Class I, II and III occlusal categories.

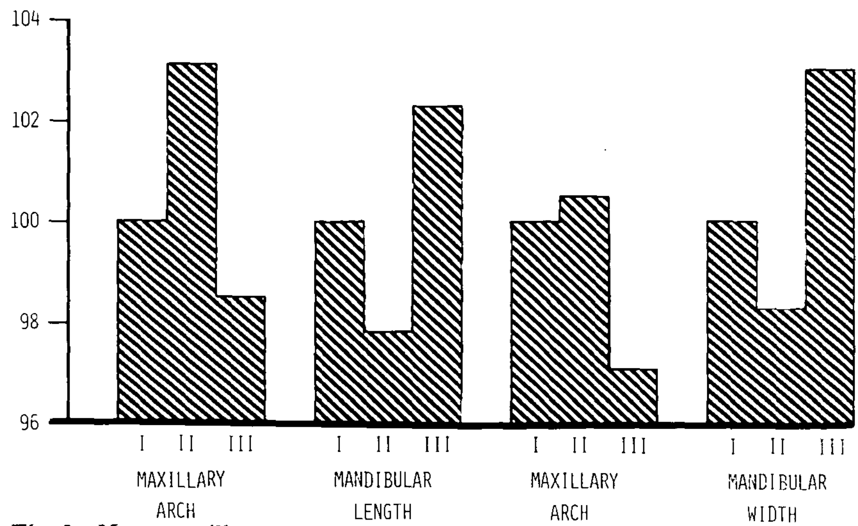

Fig. 2 Mean maxillary and mandibular arch dimensions of length and width.

Class I individuals by an average of 1.6%, whereas Class III skull dimensions were on average 1.3% larger than those of Class I subjects. The maxillary arch dimensions of width and length were 0.6% and 3.1% larger, respectively, in Class II than Class I subjects, but 2.6% and 1.5% smaller in Class III than Class I subjects, respectively. In contrast, the dimensions of mandibular arch width and length were 1.8% and 2.1% smaller, respectively, in Class II than Class I subjects, but 3.0% and 2.3% larger, respectively, in Class III than Class I individuals. Furthermore, the mesiodistal (1.3%) and buccolingual (3.1%) maxillary tooth dimensions were greater in Class II than Class I subjects, but greater in Class III than Class I subjects for the mesiodistal

TABLE II

TOOTH DIMENSIONS OF ANGLE'S CLASS I, II AND III CATEGORIES

		CLASS I		*CLASS II*		*CLASS III*	
		Mean	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*
Maxillary teeth							
1st Incisor	MD	8.8	0.20	8.8	0.11	8.2	0.26
	BL	7.3	0.16	7.2	0.17	7.0	0.17
2nd Incisor	MD	6.7	0.14	6.5	0.28	6.5	0.18
	BL	6.4	0.28	6.2	0.16	6.0	0.30
Canine	MD	7.5	0.01	7.4	0.34	7.3	0.34
	BL	8.2	0.21	8.0	0.12	8.2	0.29
1st Premolar	MD	6.4	0.11	6.4	0.13	6.4	0.19
	BL	8.9	0.07	8.2	0.18	8.0	0.19
2nd Premolar	MD	6.5	0.28	6.4	0.13	6.4	0.17
	BL	9.2	0.13	8.9	0.25	8.8	0.28
1st Molar	MD	10.7	0.16	10.5	0.19	10.3	0.36
	BL	11.5	0.28	11.2	0.26	11.1	0.35
2nd Molar	MD	9.6	0.27	9.5	0.28	9.5	0.19
	BL	11.3	0.14	11.1	0.31	10.9	0.27
Mandibular teeth							
1st Incisor	MD	5.5	0.15	5.4	0.32	5.6	0.35
	BL	6.0	0.20	6.0	0.08	6.1	0.15
2nd Incisor	MD	6.1	0.26	6.1	0.41	6.2	0.30
	BL	6.4	0.30	6.4	0.26	6.5	0.27
Canine	MD	6.9	0.26	6.9	0.38	7.1	0.19
	BL	7.9	0.15	7.8	0.36	7.9	0.26
1st Premolar	MD	6.8	0.39	6.8	0.47	6.8	0.37
	BL	7.4	0.49	7.4	0.38	7.6	0.28
2nd Premolar	MD	6.9	0.36	6.8	0.47	6.9	0.25
	BL	7.8	0.38	7.7	0.28	7.9	0.18
1st Molar	MD	11.5	0.39	11.4	0.48	11.5	0.11
	BL	10.5	0.42	10.4	0.26	10.6	0.09
2nd Molar	MD	10.6	0.34	10.6	0.39	10.6	0.14
	BL	10.2	0.26	10.1	0.47	10.3	0.27

MD = mesiodistal diameter; BL = buccolingual diameter

(2.9%) and buccolingual (4.6%) tooth dimensions. Regarding the mandibular teeth, the mesiodistal (0.6%) and buccolingual (0.7%) dimensions were greater in Class I than Class II subjects, whereas the mesiodistal (0.7%) and buccolingual (1.2%) dimensions were greater in Class I than Class III individuals (Table II). Thus, apart from revealing varying patterns of contrast between the three categories of subjects examined in this study, univariate analysis of the various dimensions does not permit the subjects to be compared as a whole.

To obtain an overall picture of the contrasts between the three categories of subjects, therefore, all the dimensions were combined and subjected to a canonical analysis of discriminance. This is a multivariate statistical technique which not only enabled all the dimensions to be combined whilst eliminating any correlation between them, but also served to maximise the separation mathematically between the constituent groups.

As shown in Figure 3, canonical analysis of *all* the dimensions measured for each subject revealed significant

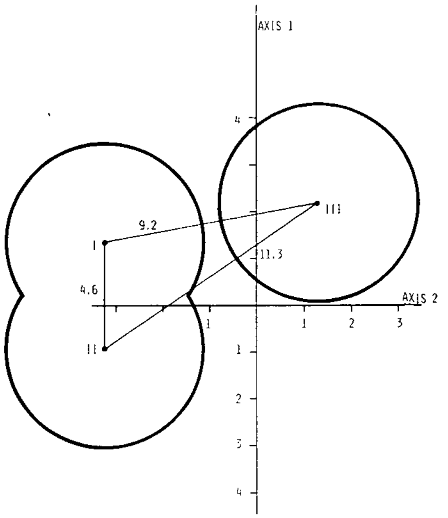

Fig. 3 Centroids and 95% confidence limits for the occlusal categories based upon analysis of all the dimensions of the body, skull, dental arches and teeth combined; generalised distances between centroids listed in standard deviation units.

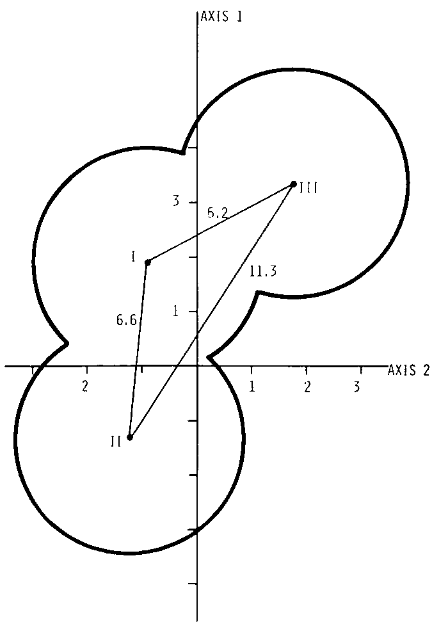

Fig. 4 Centroids and 95% confidence limits for the occlusal categories based upon analysis of all the dental arch dimensions combined; generalised distances between centroids listed in standard deviation units.

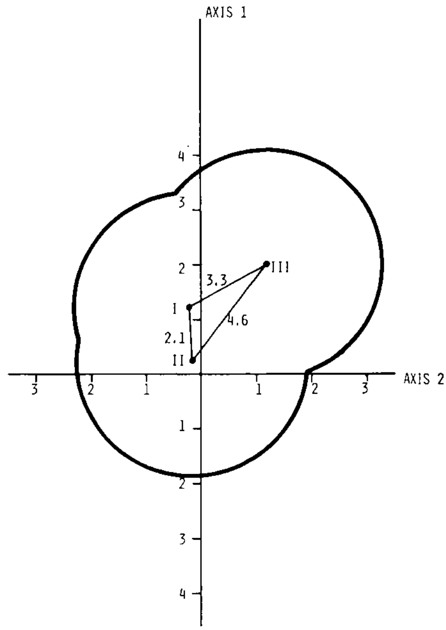

Fig. 5 Centroids and 95% confidence limits for the occlusal categories based upon analysis of all the tooth dimensions combined; generalised distances between centroids listed in standard deviation units.

discrimination between Class II and Class III categories, whereas there was no significant discrimination between Class I and Class III or between Class I and Class II categories. Similarly, canonical analysis of all the *skull, arch* and *tooth* dimensions and analysis of the skull dimensions or arch dimensions (Fig. 4) revealed significant contrasts between Class I and Class III and between Class II and Class III categories, but no discrimination between Class I and Class II categories. Finally, from analysis of the tooth dimensions combined there was no discrimination between any of the categories (Fig. 5). These overall patterns of contrast were confirmed from the generalised distance (D^2) matrix (Table III), the generalised distance statistic providing a measure of the separation between the centroids (means) for each category in terms of standard deviation units.

TABLE III

SQUARED GENERALISED DISTANCES (D^2) BETWEEN CENTROIDS OF ANGLE'S CLASS I, II AND III CATEGORIES

Dimensions included in canonical analysis	*Generalised distances between categories*		
	Class I-II	*Class I-III*	*Class II-III*
All dimensions of body, skull, dental arch and teeth combined	4.6	9.2	11.3
All dimensions of skull, dental arch and teeth combined	4.2	8.7	10.4
All dimensions of skull combined	3.7	5.4	7.9
All dimensions of dental arches combined	6.6	6.2	11.3
All dimensions of teeth combined	2.1	3.3	4.6

Discussion

Interceptive treatment in the mixed dentition stages, more efficient mechanics reducing treatment time, and early recognition of the effect of neuromuscular forces on tooth positioning all emphasise the desirability of an accurate appraisal of a patient's growth potential before treatment is initiated. The results from the present study showed varying patterns of contrast between Class I, II and III categories depending upon which dimension was compared in univariate analysis. A similar pattern of contrast between the three categories was revealed in each multivariate analysis, although the degree of discrimination depended upon which group of dimensions was analysed. This confirmed the data of Solow[6] which indicated that there were varying degrees of correlation between skull, arch, tooth and other bodily dimensions. Thus it is possible that the orthodontic categories have such a complex manifestation that only multivariate analysis permits some of the facets to be unravelled.[13] Moreover, in this study the data suggested that there are varying relationships between the skull and other bodily dimensions in subjects with different relationships between the dental arches. Thus it may be that genetic and nongenetic factors affect not only the craniofacial skeleton but other regions of the craniofacial skeleton as well. It is also conceivable that an understanding of the genetic control of the craniofacial skeleton will require further examination of the body as a whole.

The results of this study, however, must be interpreted with caution. On the one hand, the samples comprised heterogeneous rather than homogeneous Caucasoid groups from a variety of socioeconomic backgrounds. On the other hand, the subjects were divided into one of the three categories of occlusion, whereas, in fact, the categories of occlusion rather than being discrete entities merge into one another. Nevertheless the data do reveal the complexity of the relationships between the craniofacial skeleton and the remainder of the body, a feature which has yet to be appreciated in the orthodontic literature.

The unrealistic premise has been entertained that growth in absolute terms may be predicted for the postadolescent from quite immature levels of childhood. Such efforts have generally involved correlations of univariate parameters.[14] They have been valuable not so much for their findings, but for indicating the need to identify the sources and their contribution to individual differences in the growth and developmental process. The results of this study, however, indicate that recognition of dimensions, in addition to those of the dental arches and their relationships, may be pertinent to the process of prediction. Furthermore, the recognition of the multivariate nature of the problem is a first requisite in any experimental design aimed at prediction. Yet this also implies recognition of the limitations to which the precision of growth prediction can be pushed in absolute terms.

Summary and Conclusions

Univariate analysis revealed contrasting differences between subjects with Angle's Class I, II or III occlusions depending upon which bodily, skull, dental arch or tooth dimension was compared. In contrast, multivariate analysis showed that Class I could be discriminated from Class II or III categories when many dimensions were combined, although the degree of discrimination between the categories depended upon which group of dimensions was included in the analysis. Thus studies designed to interpret the differences between Class I, II or III subjects must recognise the multivariate nature of the craniofacial complex and its relationship with other bodily dimensions.

Dental School
Univ. of Birmingham
Birmingham B4 6NN
England

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