Craniofacial Width Dimensions

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The craniofacial variations and the nature of prognathism in Chinese subjects as seen in the lateral head roentgenograms have been presented in two previous papers.[1,2] This study will present the width dimensions obtained from the posteroanterior (PA) head roentgenograms of the same group of Chinese subjects. A review of the literature showed that no roentgenographic cephalometric study had been made on Chinese subjects using the PA roentgenogram.

The aims of this study are:

1. To obtain data of variations in craniofacial widths in Chinese subjects,
2. To investigate the sex differences in craniofacial structures in the width dimension,
3. To compare with data obtained by PA roentgenograms in other population groups, and
4. To correlate the width measurements with data obtained from lateral roentgenograms[1,2] in a three-dimensional study of the craniofacial variations in Chinese subjects.

Methods and Materials

The various methods of studying the width dimension using PA roentgenograms have been discussed by many investigators.[3-14] There are two basic methods of correction of magnification in the PA film: first, the use of the Wylie compensator[5] and second, correction by a mathematical formula. The present study follows the second method using geometric principles of similar triangles as described in detail by Mulick;[10] the corrections were made by a computer.

Ten variables, representing craniofacial and denture widths, were selected (Figure 1). For the purposes of this study these were defined as follows:

1. Bigonial width (go-go): the widest distance between the right and left gonions, as measured from the PA roentgenogram.
2. Bimastoid width (mas-mas): the distance between the apices of the right and left mastoid processes.
3. Bifrontozygomatic width (frz-frz): the distance between the outer edges of the right and left frontozygomatic sutures.
4. Nasal width (nas-nas): the greatest distance between the right and left lateral bony walls of the nasal cavity measured at the anterior nasal aperture.
5. Bizygomatic width (zyg-zyg): the distance between the most lateral aspects of the right and left zygomatic arches representing the total facial width.
6. Bimaxillary width (max-max): the distance between the most lateral and inferior aspects of the right and left maxillozygomatic sutures representing the greatest width of the maxilla.
7. Interorbital width (or-or): the distance between the inner bony walls of the right and left orbits, measured between the points where the radiographic shadow of the cribriform plate intersects the inner orbital margin on each side.
8. Anterior cranial base width (antcr-antcr): the distance between right and left sides of the anterior cranial base as determined by the lateral extent of the lesser wings of the sphenoid. As the exact location of the lateral extent of the lesser wing of the sphenoid may vary somewhat, this is determined by a line between the points where the radiographic shadows of the frontozygomatic processes intersect the outline of the anterior cranial base on the right and left sides.
9. Bimaxillary canine width ($\underline{3}$—$\underline{3}$): the greatest distance between the right and left maxillary canines, measured on the labial surfaces.
10. Bimandibular canine width ($\overline{3}$—$\overline{3}$): the greatest distance between the

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This paper is based on a portion of the M.D.S. thesis submitted to the University of Adelaide, South Australia.

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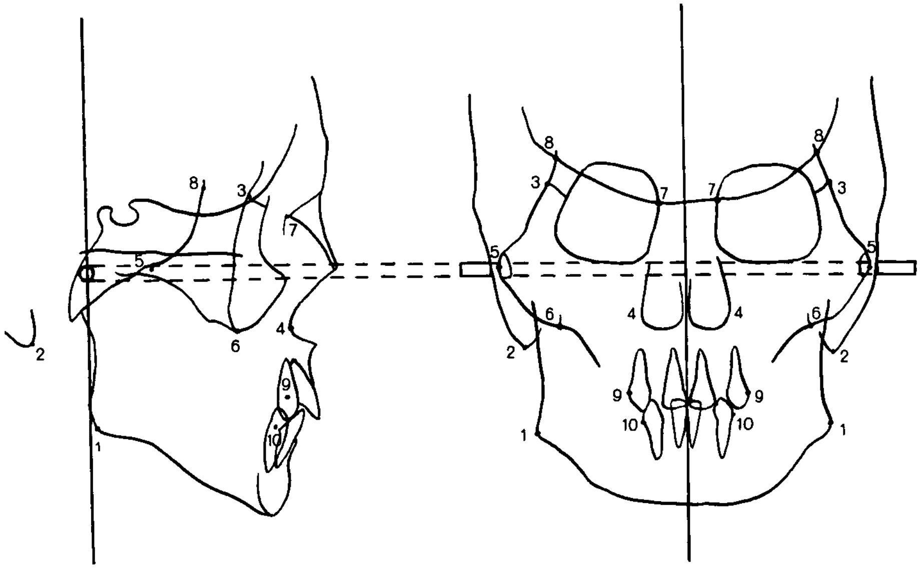

Fig. 1 Variables studied in the PA roentgenogram. See text for definitions.

right and left mandibular canines, measured on the labial surfaces.

For each width measurement on the PA roentgenogram, the corresponding distance of the landmark from the vertical porionic axis was obtained from a standardized orientated lateral film of the same subject (Fig. 1). The total number of PA roentgenograms included were those obtained from 84 males and 22 female Chinese subjects. The details of the sample have been previously described.[1]

The results of double determination tests showed that the tracing and measurement errors of the present method were small and were within acceptable levels of accuracy. Comparisons with direct measurements on skulls revealed that the positional errors and the total experimental errors were also small. The total experimental errors were considered unlikely to produce any significant error or bias in the true sample parameters.

Results and Discussions

The results obtained in this study are the first available data on the variations in width of the craniofacial structures and dental arch widths in the Chinese using PA roentgenograms.

The width measurements, after correction of magnification, were treated statistically; the arithmetic mean, ± error of the mean, standard deviation, and the range for the male and female subjects are in Table 1. The mean values of the male and female samples were compared; the sex differences and their statistical significance are also shown. The mean values of the male subjects exceeded females in nearly all skeletal width dimensions ($p = 0.001$ to 0.01); however, the mean values for interorbital width differed from zero at the probably significant level ($p = 0.05$).

The sex differences in denture widths at the maxillary and mandibular canine regions were not as great as the differences in skeletal width measurements. The maxillary canine width was higher in the male than in the female, the sex difference being probably significant ($p = 0.05$). No sex difference was found in the mandibular canine widths. A

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TABLE 1

Corrected width measurements from P. A. roentgenograms of 84 male and 22 female Chinese subjects. The values are in mm. and expressed as the arithmetic mean ± error of the mean (M ± EM), standard deviation (s) and range of variation (Range). The statistical significance of the sex differences was tested by the Student's 't-test' and the value of t are shown. ** - significant, p>0.01, * - probably significant, p>0.05.

VARIABLE	SEX	M ± EM	s	RANGE	t
go-go	M	98.3 ± 0.59	5.5	84.1 - 113.3	4.94**
	F	92.0 ± 1.00	4.7	85.7 - 100.5	
mas-mas	M	104.7 ± 0.53	4.8	94.8 - 114.0	3.17**
	F	101.0 ± 1.03	4.9	93.4 - 109.2	
frz-frz	M	105.5 ± 0.48	4.4	96.1 - 115.9	2.47**
	F	102.9 ± 0.83	3.9	97.1 - 110.4	
nas-nas	M	32.8 ± 0.36	3.3	25.2 - 40.8	3.21**
	F	30.4 ± 0.51	2.4	24.2 - 34.9	
zyg-zyg	M	132.8 ± 0.46	4.2	123.4 - 142.4	7.12**
	F	125.8 ± 0.81	3.8	119.9 - 134.2	
max-max	M	98.7 ± 0.56	5.1	88.7 - 114.2	4.95**
	F	92.7 ± 1.04	4.9	84.0 - 100.1	
or-or	M	26.7 ± 0.28	2.6	21.8 - 37.8	3.43**
	F	24.6 ± 0.53	2.5	20.3 - 31.9	
antcr-antcr	M	93.9 ± 0.45	4.1	84.5 - 107.0	2.15 *
	F	91.8 ± 0.85	4.0	86.4 - 101.3	
3/ - /3	M	39.7 ± 0.23	2.1	32.9 - 44.0	2.03 *
	F	38.7 ± 0.45	2.1	34.0 - 43.4	
$\overline{3}$/ - /$\overline{3}$	M	31.9 ± 0.23	2.1	27.2 - 37.8	0.97
	F	31.5 ± 0.35	1.6	29.2 - 35.1	

similar trend was also reported by Woods.[6]

Table 2 shows the intercorrelation of the ten width measurements. Generally speaking, the correlations were of a low magnitude and various cranial, facial and denture width dimensions were not intimately related.

The nasal bone and interorbital widths showed no significant correlation with other width measurements. On the other hand, the bimastoid width which may be regarded as an indication of the posterior cranial base width showed the greatest number of significant correlation coefficients. The bizygomatic width was significantly correlated with bifrontozygomatic, bimaxillary, bimastoid and bigonial widths. The bigonial width was poorly correlated with other width variables except bimastoid and bizygomatic widths. Thus the width of the mandible at the gonion was related to the rest of the craniofacial widths to a very minor degree.

The correlation between maxillary and mandibular intercanine widths and other skeletal widths were not statistically significant, except for three coefficients which were probably significant ($p = 0.05$). Both the maxillary and mandibular denture arch widths at the canine region were not intimately related to other skeletal widths.

The moderate positive correlation ($r = +0.42$) between the maxillary and

TABLE 2

Intercorrelation between width measurements of the head and face. The levels of significance of of correlation coefficients are shown.

VARIABLES	go-go	mas-mas	frz-frz	nas-nas	zyg-zyg	max-max	or-or	antcr-antcr	3/ - /3
mas-mas	+0.36**	-							
frz-frz	+0.15	+0.31**	-						
nas-nas	+0.03	+0.08	-0.23*	-					
zyg-zyg	+0.32**	+0.44**	+0.48**	+0.04	-				
max-max	+0.27*	+0.55**	+0.06	+0.18	+0.45**	-			
or-or	+0.23*	+0.11	+0.14	+0.14	+0.14	-0.06	-		
antcr-antcr	+0.13	+0.30**	+0.56**	-0.01	+0.41**	+0.23*	+0.26*	-	
3/ - /3	+0.17	+0.19	+0.22*	+0.02	+0.23*	+0.16	+0.16	+0.07	-
$\overline{3}$/ - /$\overline{3}$	+0.18	+0.22*	+0.10	+0.14	+0.15	+0.09	+0.22	+0.22	+0.42**

** Significant at the 1% level
* Significant at the 5% level

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mandibular canine widths is an interesting finding as it suggests that a discrepancy of maxillary and mandibular arch widths probably occurred to a much lesser extent than anteroposterior arch length discrepancies.

Table 3 compares the width measurements in this study with a group of fifteen-year-old American white subjects reported by Woods.[6] The results showed that the bizygomatic and bigonial widths in the Chinese adults considerably exceeded those of American white subjects. As the subjects studied by Woods would be expected to increase only very slightly in the width dimension from age fifteen onwards, it is reasonable to conclude that the Chinese subjects studied possessed wider faces than the American white subjects.

Table 3 also shows that the values for bizygomatic and bigonial widths of Japanese subjects[15] were very similar to Chinese subjects. In the bizygomatic width, the male Chinese and Japanese showed identical mean values, but the female Japanese had a higher mean value. The bigonial width was greater in Chinese males, but females showed almost identical mean values in the two population groups. The Chinese subjects therefore appear to have a more square face in the frontal view than the Japanese. The overall pattern appears to be a greater width at the gonion in the Chinese male and a greater bizygomatic width in the Japanese female.

TABLE 3

Comparison of selected facial width measurements of the present study with 15 year old male and female white subjects reported by Woods.

		Present study 84M and 22F Chinese adults		Woods[6] 14M and 14F 15 year old American White subjects		Enoki, et al[15] 71M and 19F Japanese subjects	
VARIABLE	SEX	MEAN	RANGE	MEAN	RANGE	MEAN*	RANGE
Bizygomatic width	M F	132.8 125.8	19.0 14.3	124.70 120.58	11.5 13.0	132.80 127.53	127.0-153.0 124.0-144.0
Bigonial width	M F	98.3 92.0	29.2 14.8	93.25 87.70	11.5 13.0	97.35 91.74	98.0-123.0 94.0-117.0
Maxillary canine width (3/ - /3)	M F	39.7 38.7	11.1 9.4	38.62 38.29	11.0 6.0		
Mandibular canine width (3/ - /3)	M F	31.9 31.5	10.6 5.9	31.04 30.29	4.0 5.5		

* Mean values have been corrected for magnification from the original data.

Correlations of Width Variables With Measurements Obtained From the Lateral Roentgenogram

The ten width variables were correlated with all the linear and angular variables obtained from the lateral roentgenograms described previously.[1,2] The linear and angular measurements of craniofacial height, depth, the angles of prognathism and the cranial base, and the measures of angulation of the jaw bases totalled 48 in number. Thus, 480 correlation coefficients were calculated. Out of 480 coefficients, only 42 were significantly correlated while another 38 were in the probably significant category. Only the significant correlations have been included in Tables 4 and 5.

Of the significant correlations, none could be classed as high, and most were in the low category where the value of r was under ± 0.40. Only six correlation coefficients were moderately correlated with values of r ranging from 0.41 to 0.51.

Generally speaking therefore, the width dimensions were poorly correlated with craniofacial linear and angular measurements in the other two dimensions. It should also be stated that many of the relationships as indicated by significant correlation coefficients are not clearly understood and care should be used in the interpretation of very low coefficients.

(1) *Correlation between width and cranial base measurements*

The anterior median cranial base (n-s) and total median cranial base (ba-n) lengths were correlated significantly with the bifrontozygomatic width

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TABLE 4

Correlations between four width measurements and craniofacial variables obtained from lateral roentgenograms of 84 male adult Chinese subjects. Only the significant correlation coefficients* are shown.

VARIABLES	go-go	mas-mas	frz-frz	zyg-zyg
Cranial base	-	s-ba + 0.36 s-ar + 0.33 n-s-ba - 0.29	n-s +0.51 ba-n +0.36	s-ar +0.35 s-ba +0.28
Prognathism and gnathic index	pr-n-ss +0.29		ba-pr +0.34	s-n-pg +0.30 id-n-pg +0.30
Facial heights	sp-pr +0.29	n-gn +0.28 s-pm-V +0.35	n-gn +0.28 sp-pr +0.30 ar-tgo +0.33	s-pm-V +0.30 ar-tgo +0.45
Facial depths and gonial angle		tgo-tgn +0.33	pg-ar +0.41 pg-tgo +0.44 tgo-tgn +0.36	pg-ar +0.32 pg-tgo +0.35 ar-tgo-tgn -0.35
Inclination of jaw bases				NL/ML -0.30 NSL/ML -0.38 ML/FH -0.34

* Coefficients differ from zero at the p = 0.01 level of significance.

TABLE 5

Correlation between four other width measurements with craniofacial variables obtained from lateral roentgenograms. Only the significant correlations* have been included.

VARIABLES	or - or	antcr-antcr	$\underline{3/}$ - $\underline{/3}$	$\overline{3/}$ - $\overline{/3}$
Cranial base	n-s-ar-0.29	-	-	-
Prognathism and gnathic index	-	-	s-n-pr+0.34 s-n-id +0.31 s-n-sm +0.30 pr-n-ss+0.33 ba-pr +0.44 gnathic index +0.36	pr-n-ss+0.34
Facial depths	-	pg-ar +0.34 pg-tgo+0.28	pg-ar +0.41	pg-ar +0.36

* Coefficients differ from zero at the p = 0.01 level of significance.

only. On the other hand, the posterior cranial base lengths (s-ar and s-ba) were correlated with the bimastoid and bizygomatic widths. This result is interesting as it suggested that the anterior and posterior segments of the cranial base length were related to the widths at the corresponding regions. Other correlations suggested that a wider posterior cranial base was associated with a longer posterior cranial base length. In addition, there was a low negative correlation with the median cranial base angulation.

(2) *Correlations between width measurements and the angles of prognathism*

There was an almost complete lack of significant correlation coefficients between the angles of prognathism, the gnathic index and the skeletal width measurements. On the other hand, most of the angles of prognathism and the gnathic index were significantly correlated with the maxillary intercanine width. An examination of the dental casts showed a prevalence of maxillary crowding due to the comparatively greater tooth size, especially involving many of the lateral incisors. This greater tooth size in a small or average sized maxilla tends to cause a crowding of the upper anterior segment producing an increased maxillary alveolar prognathy (pr-n-ss). Thus, the greater the tooth size and hence intercanine width, the greater the maxillary alveolar prognathism, which is probably accompanied by a compensating alveolar prognathism in the mandible.

(3) *Facial height and depth correlations with width measurements*

It appears that the mandibular measurements were more moderately correlated with the width dimensions than those of the upper face or the total face. This may be related to the phenomenon of mandibular growth. The increase in length posteriorly at the distal border of the mandible invariably increases the total width of the mandible at the gonial angle and along the posterior border of the ramus, and probably causes an increase in the bicondylar width as well. The gonial angle was negatively correlated with the bizygomatic width indicating that a greater width of the face was accompanied by a more acute gonial angle. This contributed to a more square profile. A

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negative significant correlation between the bizygomatic width and the inclination of the jaw bases was also found. Thus, wider faces tended to be accompanied by square profiles with acute gonial angles in the Chinese male subjects.

Summary and Conclusions

The present study presents data for craniofacial widths in the Chinese using roentgenographic methods. The results showed:

1. Chinese adults possessed significantly greater widths of the face than fifteen-year-old American whites.
2. The bizygomatic and bigonial widths of Chinese and Japanese subjects were very similar.
3. The main sex differences in craniofacial widths were in the skeletal measurements which were significantly greater in males.
4. Sex differences in denture widths were much smaller in magnitude.
5. All width measurements were intercorrelated, but at a low level.
6. The maxillary and mandibular intercanine widths were significantly correlated and probably indicated that upper and lower arch widths generally did not show any great independent variation.
7. Wider faces tended to be accompanied by square profiles and acute gonial angles in well-developed mandibles of Chinese male subjects.
8. Variations in width measurements did not affect to any extent the degree and nature of prognathism. Denture widths, however, appeared to be more closely associated with the angles of prognathism.
9. There is much room for further research using PA roentgenograms. Multivariate procedures would provide definite advantages over the present methods employed. Furthermore, angular relationships and measurements in the PA roentgenogram are largely unexplored, and their significance remains obscure.

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Acknowledgment

I wish to express my appreciation to Drs. T. Brown and M. J. Barrett for their encouragement and advice in carrying out this study. The major cost of this project was financed by a Dental Board of South Australia Research Scholarship.

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