Malaysian Journal of Medical Sciences, Vol. 12, No. 1, January 2005 (29-38)

ORIGINAL ARTICLE

THE MAXILLARY ARCH AND ITS RELATIONSHIP TO CEPHALOMETRIC LANDMARKS OF SELECTED MALAY ETHNIC GROUP

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The objectives of this study were to estimate the maxillary arch measurements, to assess the validity of Pont's & Korkhaus' Indices; to determine the relationship between maxillary arch form with head form; and to estimate the cephalic index (CI) of the study population. A cross-sectional study was conducted on 85 mature Malay students, 28 male students (32.98%), 57 females (67.02%) attending Teachers' Training College. Their mean age was 23.9 yr, and Cephalic Index (CI) 86.4 (95% Confidence Interval 85.5-87.3). Arch and head dimensions were significantly larger in males than in females. CI was not significantly different between males and females. Means of anterior arch width (AAW), posterior-arch-width (PAW) and arch-length (Lu) were 35.57mm, 47.3mm and 18.01mm respectively. They were significantly different from their corresponding Indices. Correlation Coefficient between bizygomatic width and anterior-arch-width was 0.18 and was not significant in both sexes of the present population.

***Key words** : Dental arch form, Pont's Index, Korkhaus' Index, Malay, Cephalic Index*

Submitted-12.09.2004, Accepted-31.12.2004

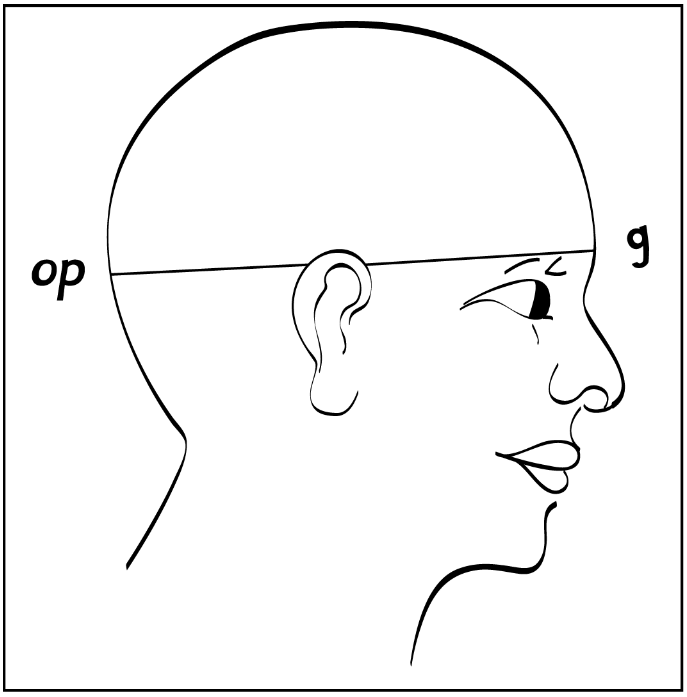
Introduction

A sound knowledge of tooth size and dental arch dimensions of a population is important for several dental treatment procedures. For example in Restorative Dentistry, where teeth is being restored to its original morphology, knowledge of the tooth size will certainly implement in the treatment administered. Differences in dental arch and head dimensions of different populations can be inherited and these inherited differences are useful for the practice of Aesthetic Dentistry and for effective orthodontic treatment(1) It is therefore important to have knowledge of certain cephalometric and dental arch parameters and their relationships for a given population. There are several indices derived from these measurements; indices of Pont(2) Linder(3), and Korkhaus(4), are mostly used in German-speaking countries(5). These indices predicts the ideal values (standard values) of the arch width and length from the sum of upper four incisors (SIu).A certain correlation exist between the arch length, width, and mesiodistal width of the upper maxillary incisors. The standard values of these indices are then statistically correlated and compared with the actual values of the individual case. Certain diagnostic and prognostic indications such as deviation in transverse development of the arch widths and anteroposterior position of incisors can be gained by comparison of the actual and standard values .

In the 1840s the Swedish physician, Anders Retzius, developed one of the most influential craniometric techniques, the Cephalic Index which measures the ratio between the width and length of the head. Generally he classified people as having one of the three types of head shapes – brachycephalic, dolichocephalic or mesocephalic(6).

The objectives of this study were to establish the dental arch indices, cephalometric measurements

Figure 1a : Diagram showing the measurement of maximum skull length (g-op)



and how these are correlated to one another, and to validate the dental arch indices in this study population.

Materials and Methods

Bootstrap statistics based on 1000 simulated means of sum of four maxillary incisors (SI_u) estimated a standard deviation of 2.3mm. This SD was used to calculate a sample of 85 subjects required to estimate SI_u with a precision of +/- 0.5 mm at 95% confidence interval.

Preliminary screening procedures were conducted among students from Teachers Training College, Kota Bharu. Subjects whose age range between 20 and 35 yr, and has Malay parents and Malay grand parents from both the paternal and maternal sides were selected for this study. Subjects with maxillary dental arch irregularities and missing teeth, and whose first-degree relatives were selected

Figure 1b : Diagram showing the measurements of maximum skull breadth (eu-eu), and maximum face width (zy-zy).

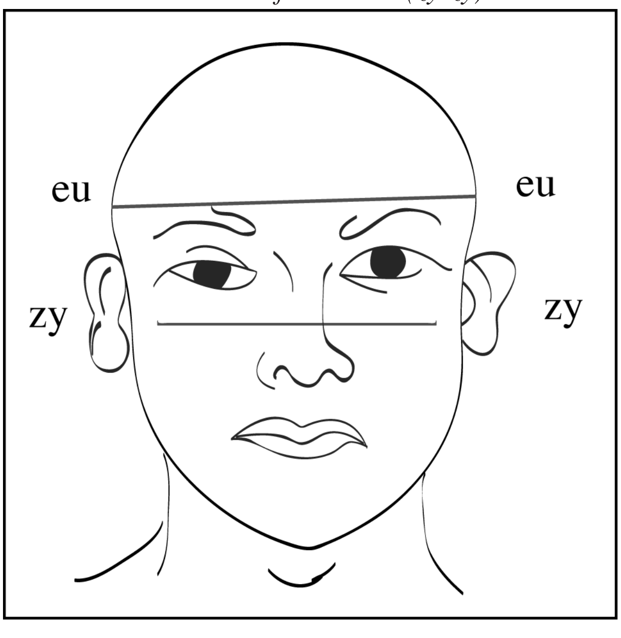
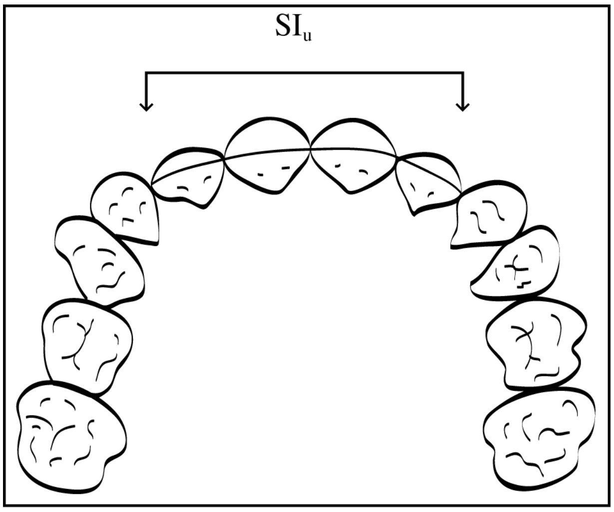


Figure 2a : Diagram showing the measurment of sum of maxillary incisors (SI_u).



for this study were excluded. Among those who were eligible, 85 subjects were consecutively selected. After a brief self-administered questionnaire session, head measurements and maxillary casts were taken. The head measurements made on the subjects were (i) maximum skull length (g-op), distance from opisthocranion (op) to glabella (g);(Fig-1a) (ii) maximum skull breadth or bieuryonic diameter (eu-eu), distance between the most lateral point of the skull(euryion), (iii) bizygomatic diameter (zy-zy), distance between two zygomatic prominences (zygion) ; (Fig-1b)

The following measurements were done on the dental casts. (i) maximum mesiodistal distance of each of the four maxillary incisors;(fig- 2a) (ii) anterior arch width (AAW), that is the distance between the lower-most points of the transverse fissure of the upper first premolar teeth, the reference points for (AAW). (iii) posterior arch width (PAW), the distance between the point of intersection of the transverse fissure with the buccal fissure of the upper first permanent molar teeth (the reference points for PAW);(Fig-2b) (iv) anterior arch length L_u, which is perpendicular from the most anterior labial surface of the central incisors to the connecting line of the reference points of AAW;(Fig-2c). All measurements were in millimeter to the nearest 0.1 mm.

Data Analysis

STATA 7.0 (7) was used to summarize the data and validate the indices using correlations and regression statistics. From the measurements made on dental casts, the sum of upper incisor mesiodistal distances (SI_u) was first computed and this measure was used to estimate the values of arch widths, using Pont's Index, for AAW and for PAW. Values of arch length (L_u) were computed using Korkhaus' Index,. These index values(standard values) were calculated

Figure 2b : Diagram showing the measurements of anterior and posterior arch widths of Maxilla (AAW and PAW)

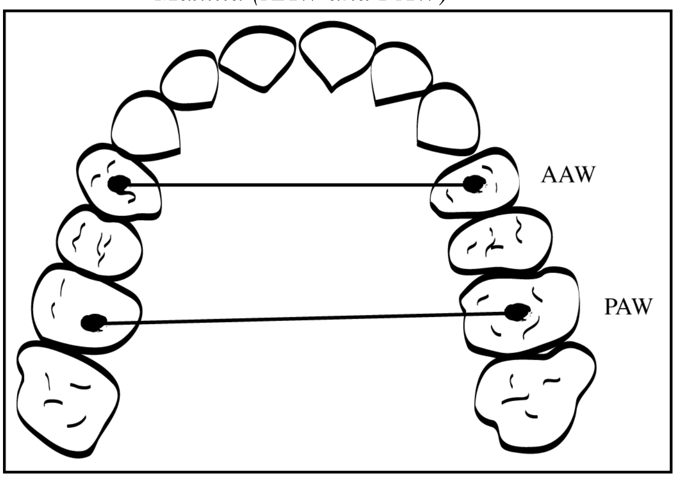


Figure 2c : Diagram showing the mesurement of arch length of maxilla (Lu)

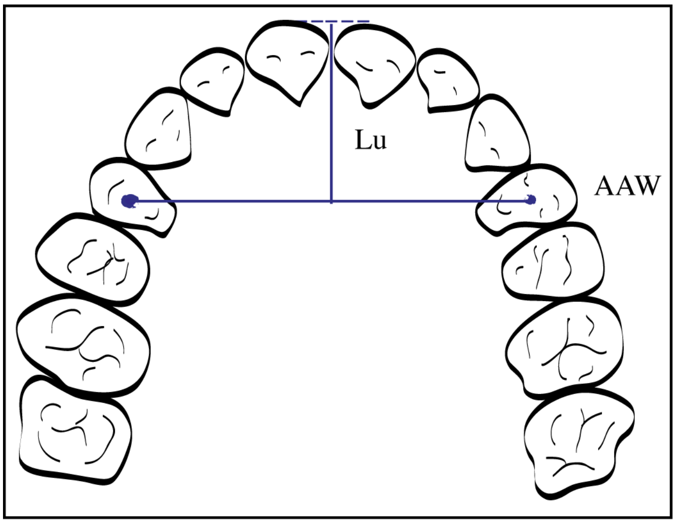


Table 1: Dental arch measurements among Malay men and women.

Dental Arch Measurements (DAM)	Gender				Total	
	Male n= 28		Female n= 57		Both sexes n= 85	
	Mean	SD	Mean	SD	Mean	SD
SI_u	32.20	2.32	31.94	2.29	32.03	2.29
AAW	35.93	2.32	35.41	3.57	35.57	3.22
AAW*	37.89	2.73	37.58	2.70	37.68	2.69
PAW	48.98	2.46	46.50	6.58	47.30	5.69
PAW**	49.54	3.57	49.14	3.53	49.27	3.52
L_u	17.67	2.48	18.17	4.14	18.01	3.67
L_u***	20.23	1.45	19.96	1.43	20.02	1.43

SI_u = sum of four upper incisord
AAW = anterior arch width measured from the cast
AAW* = anterior arch width based on Pont's index: (AAW $=SI_u$*100/85)
PAW = posterior arch width measured from the cast
PAW** = posterior arch width based on Pont's index: (PAW$=SI_u$*100/65)
L_u*** = arch length measured from the cast
L_u All measurements are not significantly different between males and females (independent t-tests p >.05)

Dental Arch Measurements (DAM)	Mean (mm)	Beta-coefficient observed vs predicted (p-value)	Correlation Coefficient DAM vs. SI_u (p-value)	Beta-coefficient** DAM vs. SI_u (p-value)
AAW (observed) AAW* (Pont's)	35.54 37.71	0.355 (<0.001)	0.296 (<0.01) 1.0 (<.01)	0.42 (<0.01) 1.2 (<0.01)
PAW (observed) PAW** (Pont's)	48.1 49.3	0.215 (<0.05)	0.255 (<0.02) 1.0 (<0.01)	0.33 (>0.05) 1.5 (<0.01)
L_u (observed) L_u*** (Pont's)	17.8 20.03	0.779 (<0.001)	0.478 (<0.001) 1.0 (<0.01)	0.46 (<0.01) 6.3 (<0.01)

Independent t test showed that predicted dental arch measurements were significantly greater than the observed measurements at p <0.01

Observed vs Predicted Dental Arch Measurements	Differences in mm (Observed vs Predicted)				% within +/-1 mm
	Maximun	Minimun	Mean	95% Confidence Interval	
AAW vs AAW**	-17	+8.4	-2.2	-2.9 to -1.4	20.7
PAW vs PAW**	-10.3	+12.0	-1.2	-2.1 to -0.35	19.5
L_u vs L_u***	-2.4	+8.4	+2.2	1.6 to 2.6	21.95

AAW = anterior arch width measured from the cast

AAW* = anterior arch width based on Pont's index: (AAW $=SI_u$*100/85)

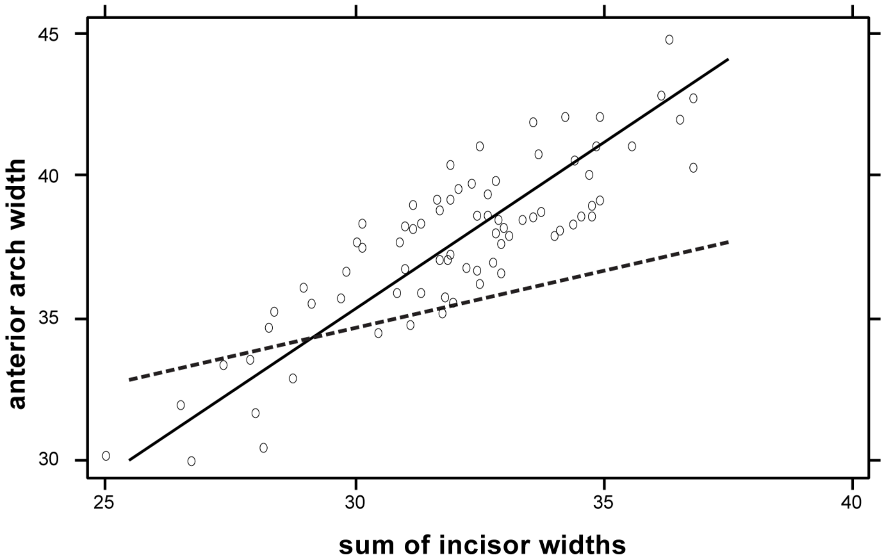
PAW = posterior arch width measured from the cast

PAW** = posterior arch width based on Pont's index: (PAW$=SI_u$*100/65)

L_u = arch length measured from the cast

L_u*** = arch length based on Korkhaus' index: $L_u=SI_u$*100/160)

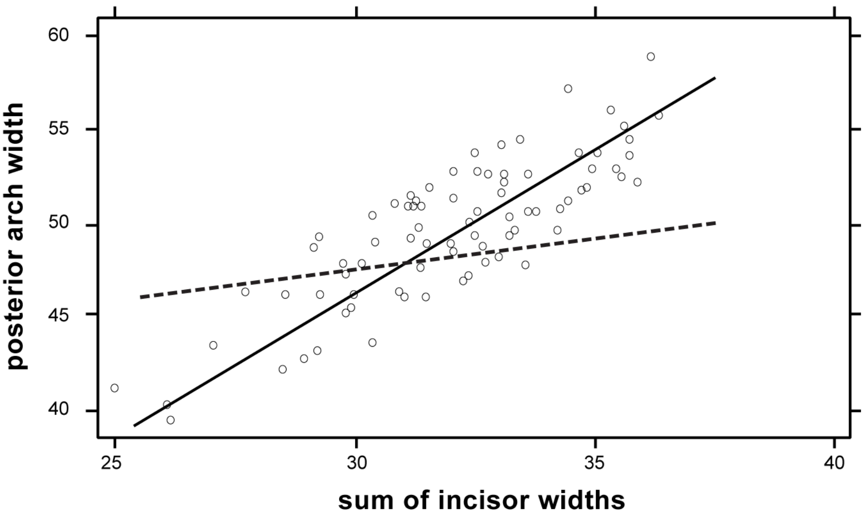
Figure 3 : Correlations of observed and expected values of anterior arch width and sum of incisor widths



Predicted values of anterior arch width by regression of sum of incisor widths on Pont's Index.

Predicted values of anterior arch width by regression of sum of incisor widths on observed anterior arch width.

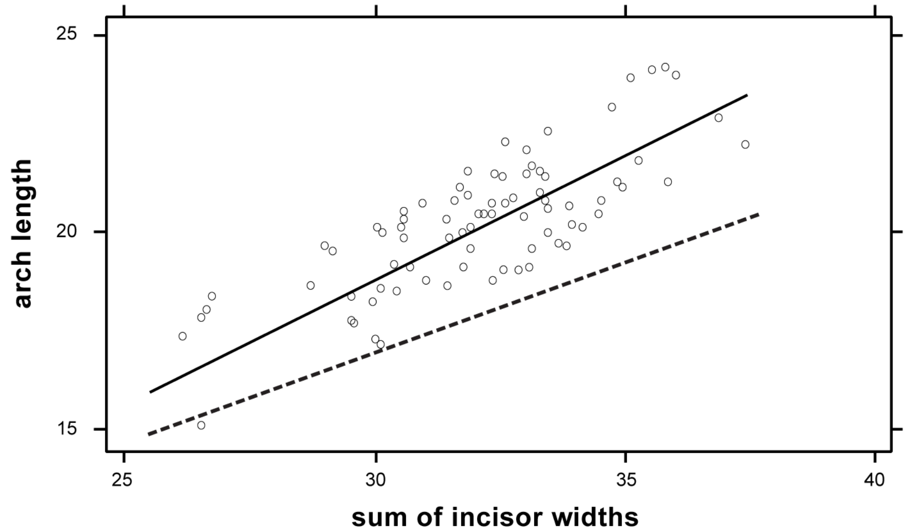
Figure 4 : Correlations of observed and expected values of posterior arch width and sum of incisor widths



Predicted values of posterior arch width by regression of sum of incisor widths on Pont's Index.

Predicted values of posterior arch width by regression of sum of incisor widths on observed posterior arch width.

Figure 5 : Correlations of observed and expected values of arch length and sum of incisor widths



Predicted values of arch length by regression of sum incisor widths on Korkhaus' Index.

Predicted values of arch length by regression of sum of incisor widths on observed arch length.

and then validated against the actual measurements made on the casts. Linear regression analysis was done between these values by fitting the regression lines, further strengthened the validity tests performed earlier.

Cephalic Index (CI) was calculated by taking the ratio between maximum skull breadth and maximum skull length. Finally, correlation between dental arch and cephalic measurements were tested.

Results

The sample comprised of 28 (33%) males and 57(67%) females of Malay ethnicity. Their mean ages were 23.9 yr and 23.2 yr respectively, and were not significantly different ($p > 0.05$). Mean SI_u was 32mm (+/- 2.3mm). Table 1 shows mean and SD of the dental arch measurements made directly from the casts and those derived from SI_u values plugged into Pont's and Korkhaus formulae as shown previously. Except for L_u, males had slightly larger values than females for all the measurements, but neither of them was statistically significant. In Table 2, the dental arch measurements, as predicted by the indices, were significantly greater that those measured directly on the casts ($p <0.01$). Correlation coefficients between the two measurements were also very weak (correlation coefficient ranged from 0.26 to 0.48). The indices, which formulae depend directly on the variation of SI_u, produced perfect correlation, where as observation of AAW, PAW and L_u, on the dental casts of subjects showed very weak correlation with SI_u. Pont's Index predicts that AAW increases by 1.2 mm for every 1mm increase in SI_u; but our study showed an increment less than 0.5mm. The discrepancy for PAW was 1.5mm vs. 0.3mm. This indicates that the increase in the mesiodistal distances of the maxillary incisors in this study did not necessarily increase the size of the dental arch measurements proportionately. Table 3 depicts the distribution of differences between observed and expected dental arch measurements. Figures 3 to 5 illustrate the comparisons of the regression coefficients between summation of incisors and dental arch measurements (observed vs expected). The regression lines predicted from the Pont's and Korkhaus' Indices were highly correlated with the sum of incisor widths whereas the observed dental arch measurements was not in proportion to the incisor widths.

In Table 4, head measurements were seen to be significantly larger among males by a difference of 3mm to 6mm ($p <.01$). The mean cephalic index (CI) of the study subjects was found to be 86.4%,

Table 4 : Gender distribution of head measurements (in mm)

Head Measure-ments	Gender		Total
	Male n = 28	Female n = 57	Both sexes n =85
	Mean (95% Confidence Interval)	Mean (95% Confidence Interval)	Mean (95% Confidence Interval)
g_op	18.18 (178.09, 182.69)	175.5 (173.59, 177.72)	177.6 (175.57, 178.82)
eu_eu	154.9 (153.02, 156.76)	151.6 (150.43, 153.29)	152.8 (151.69, 154.01)
zy_zy	138.2 (135.30, 139.77)	133.9 (132.30, 135.73)	135.4 (133.77, 136.55)
CI (%)	85.9 (84.55, 87.33)	86.6 (85.38, 87.84)	86.4 (85.46, 87.32)

g_op = Maximum skull length

eu_eu = Maximum skull breadth (Bieryuonic diameter)

zy_zy = Maximum face width (Bizygomatic diameter)

CI = Cephalic Index = (eu_eu/g_op)* 100

All measurements except CI are significantly different between males and females at $p < 0.005$ level (independent t-test)

and the mean CI of female subjects was slightly higher than the males (86.6 vs. 85.9), but were statistically not significant. Correlation between bizygomatic diameter(zy-zy) or face width and Anterior Arch Width (AAW) was done to test the relationship of head form and arch form. They were 0.01, 0.22, and 0.18 for male, female and in total, respectively. This showed a weak correlation and all r-values were not statistically significant.

Discussion

A similar study conducted on a group of ethnic Chinese subjects reported mean anterior arch width of 35.74 (+/- 2.17mm), and mean of SI_u value of 8.85 (+/- 0.59mm) (8). These findings indicate that Chinese people seemed to have bigger tooth size than the Malays as shown in this study. Very few studies have been done to measure the dental arch and most of these studies focus on the effects of craniofacial anomalies and surgical procedures on dental arch measurements (9,10). Some studies simply describe the racial and hereditary influences on these measurements (1,11). Since our study included adults of pure Malay ethnicity, matured with no dental abnormalities, the parameters obtained may represent ethnic Malays who share the same geographical environment as our sample.

The usefulness of Pont's Index is controversial. In a study aimed to evaluate Pont's Index in the untreated, non-crowded samples of Australian Aborigines, Indonesians, and White, a considerable individual variability was noted in each population with regard to the difference between observed values and Pont's estimates, ranging from -5.9 mm to +6.2 mm (AAW) and -6.1 mm to +12.7 mm (PAW) (12) which were comparable with our results shown in Table 3. None of the subjects displayed ideal arch dimensions predicted by the Index, but values were within +/- 1.0 mm for 17.5% of the Indonesian sample, 20.6% of the Aboriginal sample, 30.8% of the White sample (12), and 19.5 to 20.7% in the Malays of this study. Dental arch width was generally underestimated by the Index in Indonesians who tended to display relatively small tooth size and large arch width. A more even distribution of estimates was noted in Australian Aborigines and White subjects, with the Aborigines showing large tooth sizes and broad dental arches, and the White subjects displaying smaller tooth size and narrow arches (12). Correlation coefficients computed between observed and expected values were low in all three populations studied (range r = 0.01 to r = 0.56).(12) These findings are comparable with this study results as shown in Table 1 and 2, and Figures 3, 4 and 5. As seen in Table 3, the Pont's indices consistently over-estimated the dental arch widths whereas Korkhaus' Index under-estimated the arch lengths of our population. The existence of negative correlation between arch width and arch length was not supported by the results of our study. In this study, subjects' arch widths did not increase proportionately with the increasing size of incisors. In a similar study, maxillary arch dimensions conducted on Chinese adult subjects revealed poor correlation between tooth size and arch width.

It is concluded that this variation could be attributed to differences in the genetic inheritance of the different races. (13).

Regarding the Cephalic Index, our study subjects were found to be brachycephalic (86.4%) with no significant gender difference. It was consistent with findings of Diament and Rodrigues, 1976 (14). The reference values for cephalic index were < 76% dolichocephalic, 76 - 80.9% mesocephalic, 81 – 85.4% brachycephalic and >_85.5% hyperbrachycephalic. (15) Generally, Chinese, Japanese, Koreans and Filipinos were characterized by having longer lateral and smaller anteroposterior dimensions relative to the Caucasians(16). The information gathered about the trend of CI over time by doing a cohort analysis of CI data of a country by ages may be used for evidence of the effect of environment on the anthropometric dimensions of a population. This fact was observed in one study which showed that the CI among Jordanians changed with the economic condition that prevailed when the person was born. (17).

There was a weak correlation between the bizygomatic width (face width) and the maxillary anterior arch width. This finding was not consistent with that reported by Sergl et al,1944 (18) where they found a strong correlation between the zygomatic width and the maxillary dental arch width. However, the analysis was based on the data obtained from the models and anthropological measurements of 50 adult German subjects with fairly eugnathic dentition, and their dental arch widths showed a perfect correlation with Pont's Indices.

In conclusion, the results for the dental arch measurements and its relationship to the head form obtained from this study should be further verified and compared with those of other ethnic groups in Malaysia..

Acknowledgement

This study was supported by the Malaysian Government through the short-term grant (No.304/PPSP/6131236). The authors would like to thank the School of Medical Sciences, and the School of Dental Sciences, Universiti Sains Malaysia for the facilites provided and finally to the staff and students from the Teachers' Training School, Kota Bharu, for without their assistance and participation, this study would not have been conducted.

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