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Mesiodistal crown diameters of the primary and permanent teeth in Southern Chinese—a longitudinal study

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SUMMARY The mesiodistal crown diameters of the primary and permanent teeth were measured on serial casts of 112 Hong Kong Southern Chinese (61 males and 51 females) taken at 5.68 and 12.31 years of age. None of the teeth showed significant sex difference in bilateral asymmetry, and significant bilateral asymmetry was found only for the upper primary second molars. The asymmetries were small and the sizes of the antimeres were averaged. Posterior teeth were generally less variable than anterior teeth in both dentitions in Chinese, which is contrary to other reports, but the anterior tooth of each morphological class was, in general, less variable than the posterior member. Male teeth were larger than those of females except for the lower central and lateral incisors in both dentitions, but the difference was not statistically significant. None of the primary teeth nor three of the permanent teeth were found to have significant sex differences in size. Percentage sexual dimorphism ranged from 0.06 to 1.97 per cent for the primary teeth and from 0.36 to 5.27 per cent for the permanent teeth. In the primary dentition, molars were the most dimorphic teeth in both arches, while upper incisors and lower canine were the least dimorphic teeth in their own arch. Among the permanent teeth, the canines were the most dimorphic and the incisors were among the least dimorphic teeth in both arches. Tooth sizes in both dentitions were, in general, larger than those of the Caucasians, comparable with Northern Chinese, but smaller than those of Australian Aboriginals.

Introduction

Data derived from odontometric studies are useful in many areas. Odontometry has long been used as a tool in anthropological research (Iscan, 1989). The seemingly minor differences in dental traits (e.g. tooth eruption, shape and size) among and within populations are interesting and important to both anthropologists and practising dentists (Bailit, 1975). These differences not only reflect the ongoing process of evolution and provide a method of studying evolutionary mechanisms, but also represent the variation that must be considered in the daily care of patients.

The mesiodistal crown diameter of teeth is an important factor which affects the alignment of teeth in the bony arches and the development of occlusion during transition of the dentition (Moorrees *et al.*, 1957). Tooth-size studies on other populations have shown that variability of tooth sizes showed no predilection for sex. Anterior teeth were in general more variable than posterior teeth, but the more anterior tooth of each morphological group was less variable than the posterior members except for the lower incisors (Barrett *et al.*, 1963; Margetts and Brown, 1978; Axelsson and Kirveskari, 1983, 1984; Garcia-Godoy *et al.*, 1985; Buschang *et al.*, 1988). Insignificant or small asymmetries were generally found which justified the use of an averaged size from the pair of antimeric teeth (Barrett *et al.*, 1963; Lysell and Myrberg, 1982; Axelsson and Kirveskari, 1983; Buschang *et al.*, 1988; Ling, 1992). Male teeth were found to be larger than those of females in all or most teeth (Barrett *et al.*, 1963; Richardson and Malhotra, 1975; Margetts and Brown, 1978; Axelsson and Kirveskari, 1983, 1984; Buschang *et al.*, 1988).

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Sexual dimorphism of various ranges was found to exist for different populations (Seipel, 1946; Moorrees, 1959; Moyers *et al.*, 1976; Lysell and Myrberg, 1982). Canines in both dentitions were found to be the most dimorphic, while the incisors were the least (Seipel, 1946; Moorrees, 1959; Garn *et al.*, 1964).

The Chinese population of Hong Kong is a mixture of people originating from different parts of China, but the majority of them have their origins from the southern part of China. The mesiodistal crown diameters of the permanent dentition of Hong Kong Chinese have been reported to be larger than those of Caucasians (Sandar *et al.*, 1983; Ling, 1992; Otani *et al.*, 1993), but there is only one published set of data on primary tooth sizes (Otani *et al.*, 1993). All these studies were cross-sectional in nature and the samples were not always derived from random procedures. The objective of the present longitudinal study was to measure the mesiodistal crown diameters of the primary and permanent teeth from serial study casts of Hong Kong Chinese children. Such standards are important as a basis for space analysis and orthodontic treatment planning. The tooth sizes will be compared in future studies with those derived from other populations, including another Chinese population from Beijing, where most people come from the northern parts of China.

Materials and methods

The sample consisted of serial dental casts of 112 Chinese children (61 males and 51 females) who were drawn from participants of a survey conducted by the Department of Children's Dentistry and Orthodontics, Faculty of Dentistry, the University of Hong Kong, in 1986–1988 when 977 children (520 males and 457 females) with a mean age of 5.75 years (SD 0.46) were examined. These subjects were randomly selected to represent the 5-year-old population of Hong Kong at that time (Wei *et al.*, 1993). Each subject was examined for caries and a panoramic radiograph and impressions of their teeth were also taken.

During 1992–1993, a re-survey of these children was scheduled. Five hundred and five children were excluded from the present study as they had either caries or restorations involving the interproximal surfaces of the primary teeth and nine children were undergoing orthodontic treatment. It was impossible to contact 248 children as they had moved; 15 had emigrated and 58 refused to participate in the study.

Among the remaining 142, 30 did not attend for the appointment and refused to come when follow-up calls were made. Hence the study sample consisted of 112 children with 61 males and 51 females. The mean age was 12.31 years (SD 0.83) with the range being 10.59–14.56 years. Their mean age at the time of the 1986–1988 survey was 5.68 years (SD 0.44) which was comparable to that of the primary sample of 977 children. Student's *t*-tests indicated that there was no significant difference in the ages for the two sexes at both 1986 and 1992 surveys ($P = 0.978$ and 0.427, respectively). They were examined again and impressions were taken. Inter-occlusal records were registered in centric occlusion with softened modelling wax.

The mesiodistal crown diameters of teeth were measured by the first author with calipers (TESA Digit-Cal SM with digital output to 0.01 mm) on the dental casts according to the method described by Moorrees and co-workers (1957). The jaws of the calipers for external measurement were sharpened carefully to allow for easy access to the contact areas of the interproximal surfaces. The inside surfaces of the jaws were cleaned with lint-free polishing cloths after the teeth in an arch were measured, or sooner if contamination of the measuring surfaces was evident. Calibration for zero was checked after each cleaning.

Teeth that were partially erupted, teeth with proximal caries or restorations, and teeth with swollen gums at the proximal areas were excluded due to the inability to locate the proximal contact areas. Dental casts were discarded when poor impression or pouring techniques rendered measurements difficult. Similarly, teeth that were broken and glued back were not included. Malformed teeth such as peg-shaped laterals, conical and microdontic laterals and canines, macrodontic teeth, and teeth with abnormal

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morphology that might make the identification of 'normal contact areas' difficult, were also excluded.

Statistical analyses were performed using the SAS/STAT® (SAS Institute Inc., Cary, NC) statistical program. The Instat®- (GraphPad Software Inc.) was employed for some *t*-tests.

Abbreviations

The followings are abbreviations for tooth types used in this paper:

Primary teeth

UA	Upper central incisor
LA	Lower central incisor
UB	Upper lateral incisor
LB	Lower lateral incisor
UC	Upper canine
LC	Lower canine
UD	Upper first molar
LD	Lower first molar
UE	Upper second molar
LE	Lower second molar

Permanent teeth

U1	Upper central incisor
L1	Lower central incisor
U2	Upper lateral incisor
L2	Lower lateral incisor
U3	Upper canine
L3	Lower canine
U4	Upper first premolar
L4	Lower first premolar
U5	Upper second premolar
L5	Lower second premolar
U6	Upper first molar
L6	Lower first molar

Results

Representativeness of the study sample

This study sample of 112 children comprised only 11.5 per cent of the primary sample of 977. In order to assess the representativeness of children in Hong Kong, the mesiodistal crown diameters of the primary teeth of these 112 children were compared with a random group of 50 children (27 males and 23 females) drawn from the primary sample of 977 children collected during 1986. None of the differences were significant at $P < 0.05$ using a two-tailed *t*-test. Sex distributions were virtually the same. Hence this study sample was taken to be representative of children in Hong Kong of Southern Chinese ancestry.

Method error

Measurement error was assessed by duplicate measurements of 25 sets of dental casts randomly drawn from each survey at a 3-monthly interval. The sizes of the antimeric teeth were not averaged for the study of method error. The method error was assessed by calculating the standard deviation of a single determination by the method of Dahlberg (1940) according to the following formula: $\sqrt{(\Sigma D^2)/2N}$, where D is the difference between the duplicate measurements and N is the number of duplicate measurements.

The method error for the primary teeth ranged from 0.05 to 0.12 mm, with a mean of 0.09 mm. UE and LE had the highest method error values (0.12 and 0.11 mm, respectively), followed by LC (0.10 mm).

The method error for the permanent teeth was slightly lower than that found for the primary teeth. The values ranged from 0.04 to 0.11 mm with a mean of 0.07 mm. U6 had the highest method error value (0.11 mm) followed by L6 (0.09 mm).

These errors were smaller than or comparable with those determined by other researchers and were acceptable for the study of tooth sizes.

Bilateral asymmetry of mesiodistal crown diameters

Differences in the mesiodistal crown diameters between the right and left members of antimeric teeth were assessed. Normality of the bilateral asymmetry distribution was assessed with the Shapiro–Wilk test. As only UD and L5 showed reasonably normal distribution, non-parametric statistical methods were used to analyse the data related to bilateral asymmetry. Sex difference for the bilateral asymmetry was assessed with the non-parametric Wilcoxon signed rank sum test.

Primary teeth As only one tooth (LC) showed a significant sex difference at the 5 per cent level, the bilateral asymmetry was assessed with sexes pooled (Table 1a). Four of the P values were

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Table 1a Bilateral asymmetry (mm) of the primary teeth with sexes pooled.

Tooth type	Number of pairs	Mean	SD	Rank†
UA	97	0.018	0.121	4
UB	105	0.036*	0.144	9
UC	103	0.034*	0.158	8
UD	109	−0.001	0.118	1
UE	106	−0.056*	0.197	10
LA	83	0.022	0.115	6
LB	98	0.013	0.153	3
LC	107	0.018	0.128	4
LD	109	−0.001	0.167	1
LE	106	0.025*	0.184	7

†Rank is the arrangement of absolute values of asymmetry in ascending order.
$^*P < 0.05$.

Table 1b Bilateral asymmetry (mm) of the permanent teeth with sexes pooled.

Tooth type	Number of pairs	Mean	SD	Rank†
U1	110	−0.006	0.129	4
U2	105	−0.004	0.199	1
U3	78	0.040	0.135	11
U4	99	−0.008	0.137	5
U5	90	−0.004	0.167	1
U6	109	−0.022	0.181	10
L1	107	0.018	0.106	9
L2	106	0.014	0.137	6
L3	105	0.004	0.163	1
L4	94	0.017	0.140	8
L5	90	0.014	0.111	6
L6	100	0.051*	0.201	12

†Rank is the arrangement of absolute values of asymmetry in ascending order.
$^*P < 0.05$.

smaller than 0.05, with UE having the most statistically significant P value, followed by UB, UC and LE. For these four asymmetries, the magnitude of the difference between the antimeres was actually small. Therefore the averaged width of antimeres was used as the measurement for that tooth type in later statistical analysis.

Permanent teeth None of the asymmetries were shown to have a statistically significant sex difference at the 5 per cent level. Therefore bilateral asymmetry was assessed with the sexes pooled (Table 1b). U2, U5 and L3 were the least asymmetric (0.004 mm), while L6 and U3 were the most asymmetric (0.051 and 0.040 mm, respectively). L6 was the only tooth with a significant bilateral asymmetry at the 5 per cent level and its measured asymmetry was small. Thus pooling the antimeric teeth together for further statistical analysis would be justified.

Mesiodistal crown diameters and sexual dimorphism

Primary teeth Parametric statistical methods were used to analyse the data as none of the mesiodistal crown diameters showed significant non-normal distribution. The coefficients of variation showed no evidence that the tooth size for one sex was more variable than that of the other sex (Table 2). The molars were less variable than the incisors. The variation in the upper incisors in both sexes reflected the usual trend that the anterior member of the teeth of the same morphological class was less variable. Variabilities between the molars were either comparable to each other or the anterior member was more variable. The lower incisors also had comparable variabilities.

Sexual dimorphism was assessed by the method described by Garn and co-workers (1964). The percentage sexual dimorphism ranged from 0.06 per cent (UA) to 1.97 per cent (UD). The molars and LA were the most dimorphic teeth, while the upper incisors were the least dimorphic.

The significance of the sex difference was assessed using the independent t-test for two samples. The folded form of the F statistic, F', tests revealed no significant difference between the comparing variances. Although male teeth were larger than females, except for the two lower incisors, none of the male/female differences were significant at the 5 per cent level. Therefore when the mesiodistal crown diameters of the primary teeth were compared, pooling of the sexes together would be justified.

Permanent teeth Normality of the distribution of the mesiodistal crown diameters of permanent teeth was assessed with the sexes

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Table 2 Mesiodistal crown diameters (mm) and sexual dimorphism of primary teeth.

Tooth type	Sex	Number of teeth	Mesiodistal crown diameters			Sexual dimorphism		
			Mean	SD	CV	Difference (M – F)	% Dimorphism	Rank
UA	M	54	6.682	0.397	5.9	0.004	0.06	1
	F	47	6.678	0.346	5.2			
UB	M	59	5.461	0.361	6.6	0.017	0.31	2
	F	49	5.445	0.361	6.6			
UC	M	58	6.742	0.354	5.3	0.061	0.91	5
	F	48	6.681	0.366	5.5			
UD	M	60	7.406	0.394	5.3	0.143	1.97	10
	F	50	7.263	0.376	5.2			
UE	M	60	9.256	0.475	5.1	0.094	1.02	6
	F	49	9.162	0.444	4.9			
LA	M	51	4.168	0.286	6.9	−0.046	−1.10	7
	F	37	4.214	0.278	6.6			
LB	M	58	4.667	0.342	7.3	−0.038	−0.81	4
	F	48	4.705	0.313	6.6			
LC	M	59	5.900	0.320	5.4	0.019	0.32	3
	F	50	5.881	0.346	5.9			
LD	M	60	8.184	0.464	5.7	0.089	1.10	7
	F	50	8.095	0.468	5.8			
LE	M	60	10.295	0.473	4.6	0.149	1.47	9
	F	49	10.146	0.404	4.0			

†Rank is arrangement of the absolute values of percentage dimorphism in ascending order.

separated. As only one tooth (L6 in males) showed a statistically significant non-normal distribution at the 5 per cent level, parametric statistical tests were used to analyse the mesiodistal crown diameters of the permanent teeth. The coefficients of variability showed that the magnitudes varied at random between the sexes (Table 3). When each morphological group was assessed separately, the more anterior tooth was usually less variable, except for the lower incisors of the males and lower premolars of the females.

Percentage sexual dimorphism ranged from 0.36 per cent (L2) to 5.27 per cent (L3). The canines were the most dimorphic teeth, while the incisors were the least dimorphic. Male teeth were found to be larger than females except for the two lower incisors. Among the 12 sex differences, three (U3, U6 and L3) were statistically significant at the 1 per cent level and U4 and L5 were statistically significant at the 5 per cent level. Hence the mesiodistal crown diameters of the permanent teeth were assessed and investigated separately for the two sexes.

Discussion

The tremendous loss of sample could partly be due to the high mobility of the Hong Kong population. Changes of properties and addresses are not uncommon and this could account for the loss of 53 per cent of the subjects at follow-up. Although the present sample of 112 subjects only represented 11.5 per cent of the initial 5-year-old group, the two samples were found to be comparable in terms of age, sex distribution, and also in the size of each primary tooth. Only children with no proximal caries and restorations at age 5 were included for the present study. This would possibly underestimate the actual tooth sizes of the population because a few researchers have indicated a possible predilection of large teeth for caries (Paynter and Grainger, 1961; Hunter, 1967; Lavelle, 1974).

The method error of the present study was found to be smaller or comparable with that determined by other authors. The use of the calipers with a digital display has greatly reduced eye fatigue and reading error. Axelsson and

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Table 3 Mesiodistal crown diameters (mm) and sexual dimorphism of the permanent teeth.

Tooth type	Sex	Number of teeth	Mesiodistal crown diameters					Sexual dimorphism		
			Mean	SD	CV	Max.	Min.	Difference (M – F)	% Dimorphism	Rank†
U1	M	60	8.728	0.508	5.8	9.650	7.498	0.067	0.77	3
	F	50	8.661	0.459	5.3	9.530	7.655			
U2	M	58	7.175	0.600	8.4	8.483	5.753	0.052	0.73	2
	F	48	7.123	0.499	7.0	8.115	5.520			
U3	M	48	8.297	0.411	5.0	9.135	7.075	0.282**	3.52	11
	F	45	8.015	0.400	5.0	8.950	7.058			
U4	M	58	7.755	0.417	5.4	8.865	6.965	0.214*	2.84	9
	F	48	7.541	0.430	5.7	8.398	6.618			
U5	M	53	7.242	0.422	5.8	8.525	6.408	0.168	2.37	8
	F	44	7.074	0.468	6.6	7.888	6.018			
U6	M	60	10.413	0.502	4.8	11.945	9.413	0.301**	2.98	10
	F	51	10.112	0.453	4.5	10.963	8.810			
L1	M	60	5.476	0.328	6.0	6.398	4.848	–0.056	–1.01	4
	F	49	5.532	0.317	5.7	6.135	4.830			
L2	M	60	6.104	0.332	5.4	6.913	5.438	–0.022	–0.36	1
	F	49	6.126	0.354	5.8	6.853	5.308			
L3	M	55	7.287	0.366	5.0	7.980	6.195	0.365***	5.27	12
	F	51	6.922	0.427	6.2	7.748	5.760			
L4	M	56	7.576	0.360	4.7	8.473	6.670	0.136	1.83	6
	F	46	7.440	0.465	6.3	8.420	6.465			
L5	M	53	7.443	0.378	5.1	8.295	6.633	0.167*	2.30	7
	F	45	7.276	0.396	5.4	7.975	6.190			
L6	M	57	11.301	0.536	4.7	12.203	10.083	0.156	1.40	5
	F	51	11.145	0.440	3.9	12.005	10.198			

†Rank is arrangement of the absolute values of percentage dimorphism in ascending order.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Kirveskari (1984) found an error ranging from 0.56 to 1.79 per cent for the primary teeth of Icelandic children. Other estimates which have been reported are: 0.06–0.31 mm for Swedish dentitions (Seipel, 1946), 0.09 mm for American dentitions (Moorrees *et al.*, 1957), 0.12 mm for the primary teeth of Australian Aboriginals (Margetts and Brown, 1978), 0.09–0.13 mm for the permanent teeth of Australian Aboriginals (Barrett *et al.*, 1963), and 0.09–0.32 mm for Mulatto primary teeth of the Dominican Republic (Garcia-Godoy *et al.*, 1985). The error for the primary teeth was found to be slightly larger than that for the permanent teeth, which reflects the difficulty in locating the normal contacts for primary molars. The errors for the most distal molars were larger than those of the anterior teeth which could be explained by the difficulty in locating the 'contact points' for the last molars due to the absence of distal neighbours.

Normality of the distributions of the variables has been tested in some but not all previous studies. All primary and permanent teeth, except L6 in males, showed normal distribution in the present study, but the distributions of bilateral asymmetries were found to be mostly non-normal which entailed the use of non-parametric tests. These generally agreed with previous reports (Margetts and Brown, 1978; Buschang *et al.*, 1988).

Bilateral asymmetry of the present sample was found to be statistically significant at the 1 per cent level for only one primary tooth (UE), and the amount of this asymmetry was actually small. Therefore averaging the sizes of antimeric teeth would not significantly affect the distribution. This agreed with the usual practice that

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Table 4 Difference (mm) between the mesiodistal crown diameters of the primary teeth of Hong Kong Chinese and those of the other populations.

Tooth type	Australian Aboriginals	Swedes	Icelanders	American Whites	Beijing Chinese
Male					
UA	–0.668***	0.272***	0.192	0.272***	–0.038
UB	–0.539***	0.231***	–0.069	0.201***	–0.119
UC	–0.668***	–0.118*	–0.238***	–0.018	0.012
UD	–0.144*	0.466***	0.236***	0.666***	–0.024
UE	–0.394***	0.656***	0.256***	0.416***	0.036
LA	–0.342***	0.108*	–0.102	0.108*	–0.102
LB	–0.343***	0.017	–0.033	0.027	–0.083
LC	–0.410***	0.040	–0.040	0.060	–0.010
LD	–0.066	0.544***	0.204*	0.364***	–0.076
LE	–0.595***	0.795***	0.185*	0.395***	0.135
Female					
UA	–0.522***	0.368***	0.248*	0.198**	0.008
UB	–0.485***	0.295***	0.165*	0.155*	0.025
UC	–0.529***	–0.019	–0.219***	0.051	0.151*
UD	–0.017	0.513***	0.223**	0.653***	0.043
UE	–0.258**	0.782***	0.192*	0.422***	0.162
LA	–0.216	0.214***	0.314*	0.114*	0.024
LB	–0.205*	0.135**	0.135	0.025	0.015
LC	–0.279***	0.141**	0.061	0.061	0.121*
LD	–0.025	0.685***	0.285***	0.385***	0.005
LE	–0.494***	0.836***	0.196*	0.416***	0.146

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

teeth on one side of the jaw, or the averages of the two sides, could be used for analysing the size of teeth (Seipel, 1946; Barrett *et al.*, 1963; Margetts and Brown, 1978).

The pattern of relative variability of tooth sizes (Barrett *et al.*, 1963; Margetts and Brown, 1978; Axelsson and Kirveskari, 1983, 1984; Garcia-Godoy *et al.*, 1985; Buschang *et al.*, 1988) was better reflected in the permanent dentition of the present study. There was no predilection of variability for sex, and the anterior teeth were more variable than posterior teeth in both sexes in both dentitions. The pattern of variability within each morphological group was again better reflected in the permanent dentition than the primary. The relative variability between premolars and between lower incisors was very similar, or a reversal of the usual pattern was found. Ling (1992) measured the permanent tooth sizes on a larger sample (132–260 for each sex) of 12-year-old Hong Kong Chinese and showed a similar pattern to that found for the present study.

The present investigation found that the male teeth were larger than those of the females except for the two lower incisors in both dentitions, but statistically significant sex differences were only found in five permanent teeth, not including the lower incisors. Hence the primary tooth sizes were investigated with the sexes pooled while the permanent tooth sizes were assessed separately. The canines showed the largest sex difference within the permanent teeth, but the primary canines were not the most dimorphic teeth. The literature reveals large variations among populations when sex differences are addressed. Australian Aboriginal teeth were found to be larger for males and the differences were significant in five primary teeth (Margetts and Brown, 1978) and all the permanent teeth except the lower first premolar (Barrett *et al.*, 1963). Six of the 10 Icelandic primary teeth were significantly

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Table 5 Difference (mm) between the mesiodistal crown diameters of the permanent teeth of Hong Kong Chinese and those of the other populations.

Tooth type	Australian Aboriginals	Swedes	Icelanders	American Whites	Beijing Chinese
Male					
U1	–0.622***	–0.122	–0.262***	–0.182*	0.048
U2	–0.475***	0.315***	0.225**	0.295**	0.065
U3	–0.013	0.247***	0.157*	0.307***	0.257**
U4	0.065	0.715***	0.530***	0.995***	0.325***
U5	0.052	0.502***	0.352***	0.572***	0.342***
U6	–0.927***	0.353***	–0.567***	–0.167*	–0.097
L1	–0.394***	–0.004	–0.114*	–0.064	–0.044
L2	–0.496***	0.054	–0.096	0.064	0.014
L3	–0.203**	0.287***	0.157*	0.327***	0.147*
L4	0.086	0.568***	0.276***	0.686***	0.306***
L5	–0.117	0.443***	–0.007	0.223**	0.193*
L6	–0.739***	0.641***	–0.149	0.591***	–0.079
Female					
U1	–0.339***	0.121	–0.089	–0.009	0.251**
U2	–0.217*	0.493***	0.293***	0.343***	0.113
U3	0.065	0.345***	0.225***	0.525***	0.145
U4	0.011	0.691***	0.471***	0.941***	0.171*
U5	0.064	0.454***	0.234**	0.574***	0.184
U6	–0.808***	0.322***	–0.588***	–0.068	–0.248**
L1	–0.148*	0.162**	0.052	0.072	0.152*
L2	–0.234***	0.216***	0.106	0.206***	0.106
L3	–0.088	0.302***	0.122	0.342***	0.102
L4	0.080	0.590***	0.320***	0.660***	0.210*
L5	–0.034	0.396***	0.006	0.206*	0.116
L6	–0.565***	0.695***	–0.075	0.755***	–0.245*

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

larger for males (Axelsson and Kirveskari, 1984) and all but one of the permanent teeth were significantly larger for the male (Axelsson and Kirveskari, 1983). For the Mulatto primary teeth of the Dominican Republic (Garcia-Godoy *et al.*, 1985), male teeth were in general larger, except for the upper lateral incisors, but only significantly different for the lower central incisor. Male French-Canadians were found to have significantly larger teeth (Buschang *et al.*, 1988), and in American male Negroes, all teeth were found to be larger (Richardson and Malhotra, 1975).

In the present study, sexual dimorphism was found to be smaller in the primary teeth (0.06–1.97 per cent) than in the permanent teeth (0.36–5.27 per cent) which agreed with the results found in other populations (Seipel, 1946; Moorrees, 1959; Black, 1978). The figures were generally comparable with the reported range of 0.4–3.9 (Seipel, 1946; Moorrees, 1959; Moyers *et al.*, 1976; Lysell and Myrberg, 1982; Garcia-Godoy *et al.*, 1985; Ling, 1992). The present study also agreed with previous investigations (Seipel, 1946; Moorrees, 1959; Garn *et al.*, 1964; Ling, 1992) that the permanent canines were the most dimorphic while the incisors were the least, but this trend was not reflected by the primary dentition of the present study.

The mesiodistal crown diameters of the present population were compared with those of other populations by using two-tailed *t*-tests (Tables 4 and 5). The tooth sizes were smaller than those of the Australian Aboriginals in both dentitions (Barrett *et al.*, 1963; Margetts and Brown, 1978). Thirteen out of 20 primary teeth and 10 out of 24 permanent teeth in both sexes were smaller than the Australian Aboriginals at

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the 0.1 per cent level. One tooth from each dentition was found to be smaller at the 1 per cent level, and two teeth from each dentition were smaller at the 5 per cent level.

The present tooth sizes were, in general, larger than those of Swedes (Lysell and Myrberg, 1982). Thirteen primary teeth and 19 permanent teeth in both sexes were found to be larger than the Swedes at the 0.1 per cent level. Two more primary teeth and one more permanent tooth were larger at the 1 per cent level. Two more primary teeth were larger at the 5 per cent level.

Icelanders are claimed to have the biggest tooth size among European populations (Axelsson and Kirveskari, 1984). Significant differences at the 0.1 per cent level were found for five primary and 10 permanent teeth, with the teeth of Hong Kong Chinese being larger except for UC and U6 of both sexes and U1 in males where the sizes were smaller than the Icelanders. One more primary tooth and two permanent teeth were significantly larger in the local population at the 1 per cent level. If a critical level of 5 per cent was chosen, seven more primary teeth and three permanent teeth would be larger than the Icelanders, but L1 of the male would be smaller.

When compared with the American white population (Moyers *et al.*, 1976), 10 primary teeth and 14 permanent teeth were significantly larger in the Hong Kong Chinese at the 0.1 per cent level. One more primary tooth and two more permanent teeth were larger at the 1 per cent level. Three primary teeth and one permanent tooth were larger at the 5 per cent level. Two permanent teeth of these Hong Kong Chinese children were found to be smaller than the Americans at the 5 per cent level.

Only two primary teeth from the local population were found to be larger than Northern Chinese in Beijing (Otani *et al.*, 1993) at the 5 per cent level. Three permanent teeth were found to be larger than the Northern Chinese at the 0.1 per cent level, two more permanent teeth larger at the 1 per cent level, and four more teeth larger at the 5 per cent level. However, two permanent teeth from the study were found to be smaller than the Beijing Chinese with one at the 1 per cent level (female U6) and the other at the 5 per cent level (female L6).

In summary, the primary teeth of Hong Kong Chinese children are comparatively larger than other populations, except for Australian Aboriginals and Northern Chinese. The UC in both sexes is generally smaller than or comparable with those of other populations except for the Beijing Chinese. The permanent teeth of the Hong Kong Chinese are only second to those of the Australian Aboriginals in general. U1 has a tendency to be smaller than that of the other populations except for Beijing Chinese. U6 is larger than the Swedes but smaller than that of other populations.

When comparing the tooth sizes among different populations, the effect of caries incidence (Paynter and Grainger, 1961; Hunter, 1967; Lavelle, 1974), water fluoridation (Goose and Roberts, 1979), and secular changes (Garn *et al.*, 1968; Brace and Mahler, 1971; Lavelle, 1972; Ebeling *et al.*, 1973; LeBlanc and Black, 1974; Brace, 1980; Brace and Nagai, 1982; Lukcas *et al.*, 1983; Kieser and Cameron, 1987) may need to be addressed. A search of the literature yields contradictory results and continued research on these areas may help to explain some of the differences found among studies.

Conclusions

Mesiodistal crown diameters of permanent and primary teeth were measured on serial casts of 112 Hong Kong Chinese children (61 males and 51 females) taken at the mean ages of 5.68 and 12.31 years.

The method errors for the measurement of the primary and permanent tooth sizes were 0.09 and 0.07 mm, respectively.

Bilateral asymmetry was assessed with sexes pooled using non-parametric statistical analysis. Only one primary tooth was significantly asymmetric at the 1 per cent level and the actual magnitude was small. This justified the use of the pooling of antimeric teeth with their sizes averaged.

The variability of the tooth sizes was found to be least prominent in the posterior teeth and most prominent in the incisors for both

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dentitions of both sexes. For intra-morphological group variability, the permanent teeth generally reflected the usual pattern that the anterior member was less variable than the posterior tooth except for the lower incisors. Deviation from this pattern was greater in the primary teeth.

Male teeth were larger than the females except for the lower incisors for both dentitions. In the primary dentition, the molars and lower lateral incisors were more dimorphic than the canines, but none of the sex differences were statistically significant. In the permanent dentition, statistically significant sex differences were observed in only three teeth. Among these, the permanent canines were the most dimorphic with the differences being 0.4 and 0.3 mm for L3 and U3, respectively. Percentage sexual dimorphism was smaller for the primary teeth (0.06–1.97 per cent) than for the permanent teeth (0.36–5.27 per cent).

The mesiodistal crown diameters found in the present study were relatively large when compared with those of the other populations, being second only to Australian Aboriginals in general. The primary canines, permanent central incisors, and permanent first molars in the upper arch in both sexes were generally smaller than or comparable with other populations except for Australian Aboriginals and Northern Chinese.

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