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Anterior crown dimensions and relationship in an ethnic Chinese population with normal occlusions

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ABSTRACT: Odontometric measurements of anterior tooth crown sizes in a Chinese sample of 85 Class I occlusions were similar to those published in the white population except for larger upper lateral incisors and smaller upper central incisors in Chinese. Sex differences in tooth sizes were seen only in the maxillary and mandibular canines while differences between antimeres were not significant. The Bolton ratios of our Chinese sample revealed a Bolton ratio of 77.89±1.62 for the combined mesio-distal widths of the six mandibular anterior teeth as compared to the combined mesio-distal widths of the six maxillary anterior teeth. Surprisingly, the Bolton ratio in our sample compared favourably with those originally published by Bolton although the interfacial angles, overbite and overjet relationships were statistically different.

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INTRODUCTION

Black (1902) and Ballard (1944) were among the first to measure mesio-distal crown dimensions in North American whites. Micro differentiation in tooth dimensions in different genetic pools and populations that have been admixed or transplanted have been reported (Bailit 1975, O'Rourke and Crawford 1980, Baume and Crawford 1978). They attributed the direction of micro differentiation to be a reflection of differential amount of genetic admixture. In addition to historical and demographic factors, evolutionary factors such as gene flow was also postulated to explain variation in tooth sizes in different populations (Baume and Crawford 1978). Bailit (1975) has stressed the importance of clinicians taking into consideration these minor variation in dental traits among population types as these differences could have important effects in the prosthodontic restoration of the edentulous, diagnostic prediction of unerupted permanent teeth and various orthodontic applications.

Odontometric differences in Caucasian and Indian teeth have been reported by Nelson (1938), with the Indian teeth being generally larger than those reported on American Caucasians (Black 1902). Kellam (1982), comparing the tooth sizes of Navajo Indians to those of Caucasians, found generally larger teeth in Navajos than Caucasians. Differences in the morphology between Caucasoid and Mongoloid teeth have also been documented (Black 1902, Dahlberg 1963). The incisors of people of the Mongoloid stock has been described as shovel shaped with prominent marginal ridges.

Co-ordinating the anterior interdigitation of teeth, overjet and overbite in an orthodontically finished Class I anterior teeth relationship relies to a great extent on the relative harmony in mesio-distal widths of the maxillary and mandibular anterior teeth. Several studies expressing ratios of anterior maxillary mesio-distal cumulative tooth dimensions have been described for Caucasoid teeth (Neff 1949, Lundstrom 1954, Bolton 1958, Stifter 1958). These studies have emphasised that well finished cases require proper balance in anterior tooth mesio-distal dimensions. Using two hundred cases, Neff (1949) determined the anterior coefficient (by dividing the maxillary sum from canine to canine by the mandibular sum from canine to canine) to range from 1:1.7 to 1:4.1. He stressed that this ratio varied with the overbite status. Using fifty-five cases exhibiting excellent occlusions, Bolton (1958) determined the ratio of the six mandibular anterior teeth as compared to the six maxillary anterior teeth to be 77.2±0.22. If the ratio exceeded 77.2, there would be an excess in the mandibular canine to canine tooth size. If this ratio was less than 77.2, the excess was in the maxillary canine to canine mesio distal widths. His results were also confirmed by Stifter (1958) in a subsequent study. Sperry et al. (1977) in their study on Bolton tooth size discrepancies in Angle Class III malocclusions, noted a significantly greater frequency of excess mandibular tooth size in Angle Class III cases when compared to a control sample of non-Class III patients.

Several cephalometric studies on Chinese patients have shown that norms for incisor angulations differ (Cotton 1951, Lin 1985, Cooke and Wei 1988) from those of caucasians. These studies have revealed that the maxillary and mandibular incisors are more proclined resulting in a smaller interincisal angle. Together with the peculiar shape of Mongoloid incisors (Black 1902) and the possible variation in odontometric mesio-distal dimensions of the anterior teeth, this study was aimed at (1) establishing normative data on crown dimensions of anterior teeth in Chinese (2) determine whether the variation in incisal angulations, morphology and morphometry in the Chinese population affected the anterior Bolton ratio.

MATERIALS AND METHODS

From the completed study casts of fifty-three (22 males, 31 females) orthodontic cases and thirty-two untreated cases

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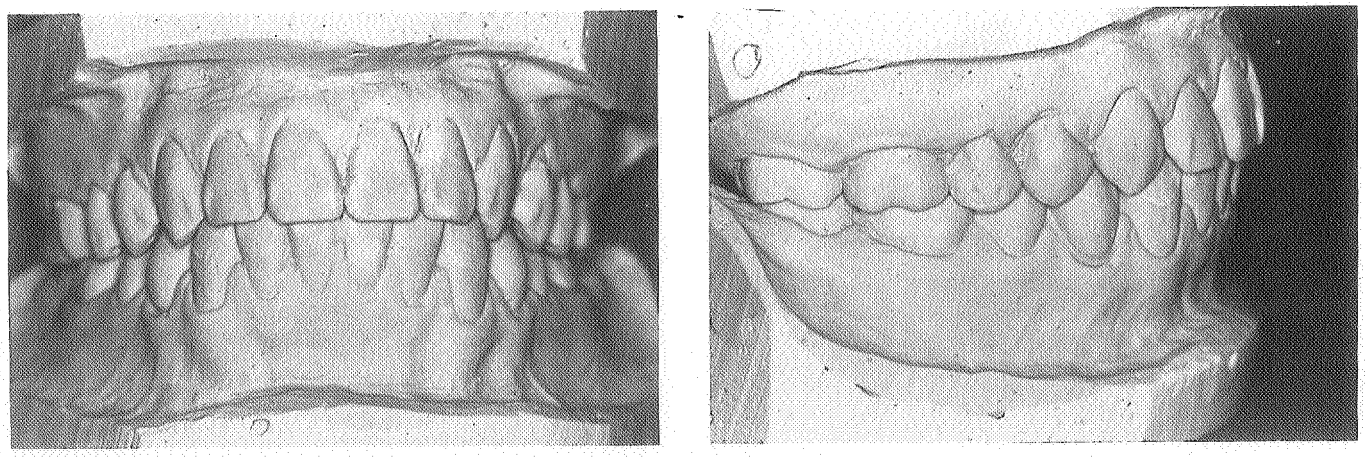

Figure 1. Frontal (a) and Lateral (b) views of typical case from the sample

(21 males, 11 females), measurements were taken of the mesio-distal widths of the six maxillary and six mandibular teeth according to the method of Bolton (1958). The subjects were aged 15 to 24 years. The study cast of the subjects selected had a full complement of upper and lower anterior teeth on both sides of the maxillary and mandibular arches. The teeth were assessed to be morphologically normal. Teeth with dental malformations like peg shaped incisors, fusion, loss of approximal tooth substance due to caries or attrition were excluded from the sample. Selection criteria was based on the condition that the occlusion was in excellent Angles Class I relationship (*Figures 1a and 1b)* for both orthodontically treated and untreated cases. In the orthodontically treated sample, teeth which had enamel stripping performed during treatment were excluded. Cases with slightly slipped contacts, minor rotations and deviations from ideal occlusion were excluded from the study. Overjet, overbite and interfacial angles had to be within normal limits (1.5-3.5mm, 10-40% and 150°-170°, respectively).

Measurements of the mesio-distal crown dimensions of the dental casts were made using needle pointed calipers to the nearest 0.05mm using procedures described by Hunter and Priest (1960) and Bishara et al. (1986). For each anterior tooth, the greatest mesio-distal diameter from anatomic mesial contact point to anatomic distal contact point parallel to occlusal plane were measured. Each tooth was measured three times and the measurements averaged. Intra and inter examiner variability was also determined.

The mesiodistal widths of the six mandibular anterior and six maxillary anterior teeth were summated and the anterior ratio of Bolton (1958) calculated thus:

$$\frac{\text{Sum mandibular 6}}{\text{Sum maxillary 6}} \times 100 = \text{Anterior ratio (\%)}$$

The interfacial angles (angle between the labial surfaces of maxillary and mandibular central incisors) were also measured off the study casts by scribing lines parallel to the upper and lower labial faces. In the orthodontically treated sample, the accuracy of the interfacial angle determined by this method was compared to that obtained via lateral cephalograms and found to be less than 2 degrees. In all cases, the overjet, overbite and maxillary incisal edge labio-lingual thickness was also measured (*Figure 2)*. The overbite was measured as the vertical overlap of the upper incisors over the lower incisors perpendicular to occlusal plane (OB1) and also as a percentage overlap of the upper central incisors to the lower incisal clinical crown length (OB2). The overjet (OJ1) was measured as the horizontal distance from the labial aspect of the maxillary central incisor edge to the labial aspect of the mandibular incisor,

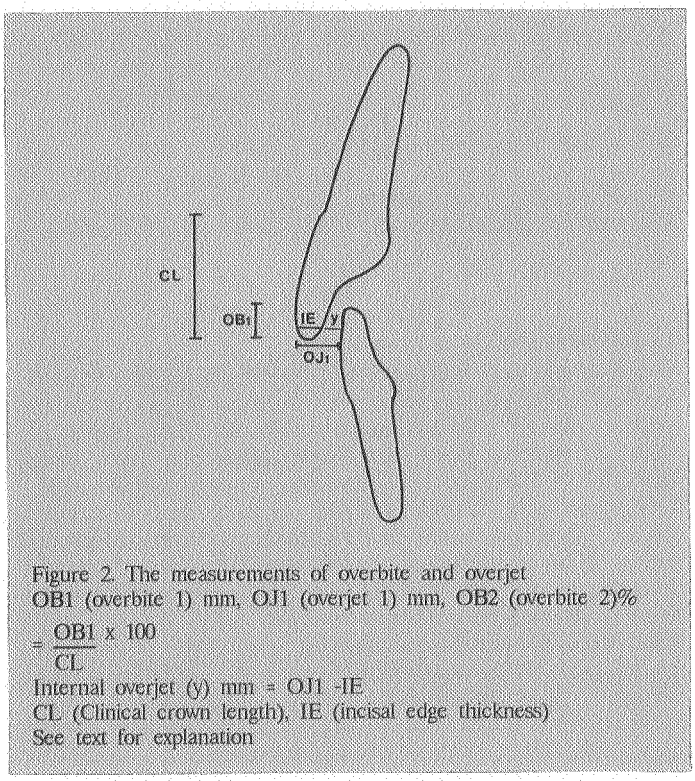

Figure 2. The measurements of overbite and overjet
OB1 (overbite 1) mm, OJ1 (overjet 1) mm, OB2 (overbite 2)%
$= \frac{OB1 \times 100}{CL}$
Internal overjet (y) mm = OJ1 -IE
CL (Clinical crown length), IE (incisal edge thickness)
See text for explanation

parallel to the occlusal plane. Another measurement (internal overjet = y) was obtained by subtracting the value of overjet (OJ1) by the labio-lingual thickness of the incisal edge (IE), which was measured with a veneer caliper.

Statistical Analysis

The mean and standard deviation were computed for the mesio-distal dimension of each anterior tooth together with the combined mesio-distal widths of the six upper anterior teeth, six lower anterior teeth and the percentage ratio of the six anterior teeth to the six lower anterior teeth (Bolton ratio). Paired student's t-tests were used to compare differences in the mean tooth sizes between males and females and also between left and right antimeres. The differences in the overjet, overbite, upper incisal edge thickness and interfacial angles were also tested.

RESULTS

The inter-examiner variability was calculated between investigators (LKKK, KSB) measuring the mesio-distal

widths of each anterior tooth in 10 cases. A difference of 1.6% was found between investigators. However, this difference was not significant at the 1% level. Intra-examiner variability was 0.8 and 0.9% for each of the investigators, respectively. A pilot study was also conducted on 10 male patients from each group to determine if there were any significant differences at $p<0.05$ in mesiodistal crown dimensions, OJ1, OJ2, OB1 and interfacial angle between the orthodontic and non-orthodontically treated samples. As the results indicated no significant differences, data from the 2 groups were combined.

The mesio-distal widths of the six upper and lower teeth are shown in *Tables 1* and *4*. Comparisons of right and left antimeres in the males and females were of very small magnitude and not clinically significant and therefore combined in the computation of *Table 1*. Although males tended to have larger teeth than females, sexual dimorphism was generally not significant except in the maxillary and mandibular canines. Compared to the females the maxillary and mandibular canines in the males were 5.0% and 4.2% larger respectively. The combined mesio-distal widths of the six upper anteriors and six lower anterior teeth was found to be 46.78±1.29mm and 36.44±1.20mm, respectively (*Table 2*). The percentage ratio (Bolton ratio) of the combined mesio-distal widths of the lower anteriors to the combined mesio-distal widths of the upper six anterior teeth was found to be 77.89±1.61%. The mean interfacial angles, overbite, overjet and incisal edge thickness are shown in *Table 3*.

DISCUSSION

The accuracy of plaster casts fabricated from alginate impressions as a representation of actual crown dimensions has been determined to be more accurate than direct measurement intra-orally (Hunter and Priest 1960). The sex differences found in our study, most noticeably in the mesio-distal widths of the upper and lower cuspids is consistent with those reported by Moorrees and Read 1964, Garn et al. 1968, Kellam 1982, Bishara et al, 1986). The odontometric measurements in our Chinese population varied with those reported on Caucasians (*Table 1*). They were statistically smaller in the upper central incisors ($p<0.01$) and larger in the upper lateral incisors ($p<0.01$). No other significant differences were found in the mesio-distal dimensions of other teeth. Bailit (1975) believes that such differences in the population types could be best

Table 1.
Mesiodistal crown diameter in present study compared to those reported on Caucasians (Moyers et al. 1976; Lysell and Myrberg 1982)

			Present Study (Chinese)		Caucasians	t value
Max	1	M	8.48 ± 0.51	] NS	8.91 ± 0.59	-4.43**
		F	8.20 ± 0.56		8.67 ± 0.57	-4.12**
Max	2	M	7.19 ± 0.43	] NS	6.88 ± 0.64	4.48**
		F	7.14 ± 0.46		6.78 ± 0.64	4.50**
Max	3	M	8.13 ± 0.45	] **	7.99 ± 0.42	0.21 (NS)
		F	7.74 ± 0.45		7.49 ± 0.36	0.17 (NS)
Mand	1	M	5.41 ± 0.40	] NS	5.54 ± 0.32	-0.18 (NS)
		F	5.38 ± 0.41		5.46 ± 0.34	-0.20 (NS)
Mand	2	M	5.98 ± 0.39	] NS	6.04 ± 0.37	-0.07 (NS)
		F	5.90 ± 0.41		5.92 ± 0.34	-0.09 (NS)
Mand	3	M	7.02 ± 0.38	]	6.96 ± 0.40	0.65 (NS)
		F	6.74 ± 0.43		6.58 ± 0.34	0.83 (NS)

] : Statistical significance between sexes
NS : Not significant
** : p>0.01

Table 2.
Sum mandibular "6", Sum maxillary "6" and Bolton ratio in present study compared to those published by Bolton

	Present Study	Bolton (1958)	t value
Mesio-distal widths of mand. "6"	36.44±1.20	-	-
Mesio-distal widths of max. "6"	46.78±1.29	-	-
Anterior Bolton ratio	77.89±1.61	77.2±1.65	1.55 (NS)

NS : Not significant

Table 3.
Interfacial angle, overbite, overjet and upper incisor edge thickness in present study compared to those published by Bolton

Parameter	Present Study	Bolton (1958)	t value
Interfacial angle	161.89±7.81°	177°	5.2**
Overbite 1 (OB1)	1.92±0.49 mm	-	
Overbite 2 (OB2)	23.39±6.04%	31.3%	9.8**
Overjet 1 (OJ1)	2.41±0.36 mm	-	
Internal Overjet (Y)	0.52±0.32 mm	0.74	8.7**
Upper incisor edge thickness (IE)	1.91±0.17 mm		

** : p<0.01

Table 4.
Mesiodistal crown measurements of anterior teeth

Maxillary		-2 SD	-1 SD	Mean	SD	+1 SD	+2 SD
1	M	7.46	7.97	8.48	0.51	8.99	9.50
	F	7.38	7.94	8.50	0.56	9.06	9.62
2	M	6.33	6.76	7.19	0.43	7.62	8.05
	F	6.22	6.68	7.14	0.46	7.60	8.06
3	M	7.33	7.68	8.13	0.45	8.48	8.73
	F	6.74	7.19	7.64	0.45	8.09	8.54
Mandibular		**-2 SD**	**-1 SD**	**Mean**	**SD**	**+1 SD**	**+2 SD**
1	M	4.61	5.01	5.41	0.40	5.81	6.21
	F	4.56	4.79	5.38	0.41	5.79	6.20
2	M	5.30	5.69	6.08	0.39	6.47	6.86
	F	5.18	5.59	6.00	0.41	6.41	6.82
3	M	6.46	6.84	7.22	0.38	7.60	7.98
	F	6.08	6.51	6.94	0.43	7.37	7.80

explained by a polygenic model of inheritance. The results show that for a racially aesthetic arrangement of artificial anterior teeth for Chinese patients, wider lateral incisors and canines could be chosen. This would often require selecting teeth sizes from different mould groups, or the creation of moulds specific to Chinese racial types.

Bolton (1958) in his study of tooth size analysis, theorised that small interincisal angles and extreme labio-lingual thickness of upper incisors tended to disrupt the anterior tooth size ratio. Several authors (Tuverson 1980, Hussels and Nanda 1987) have also demonstrated that angulation of incisors and torque of incisors can affect arch length. It was therefore surprising to find that our Bolton ratio of 77.89±1.61 compared favourably to that reported by Bolton (Bolton 1958) since the Chinese are known to have a greater degree of bimaxillary protrusion (Cotton et al. 1951, Cooke and Wei 1988) and therefore different torque angles of the incisors when compared to the whites. Our study also demonstrated a statistically significant difference ($p<0.01$) in the interfacial angle as compared to Bolton (1958). One possible explanation is that the maxillary incisor inclinations in Chinese are relatively more proclined than the mandibular incisors when compared to caucasians (Cotton et al. 1951, Lin 1985). This differential in incisor inclinations in the arches would result in the mandibular anterior teeth occupying less arch length when compared to the maxillary anterior teeth, resulting in a smaller Bolton ratio.

Neff (1949) in his study of 200 cases attempted to relate the anterior coefficient (derived by dividing the summation of the maxillary six anterior teeth into the summation of the six mandibular teeth) to the degree of overbite. He concluded that a value of 1.17 was associated with 0% overbite and 1.41 with a 100% overbite. As the Bolton ratio is the reciprocal of the anterior coefficient, it would imply that the greater the overbite the smaller the Bolton ratio. The greater the overjet, the larger maxillary anterior teeth would have to be in relation to the mandibular anterior teeth to obtain an ideal Bolton relationship. This in turn would mean a smaller Bolton ratio. Both the overjet and overbite parameters were found to be statistically smaller ($p<0.01$) in our sample as compared to those published by Bolton. Theoretically, one could expect a larger Bolton ratio.

This larger Bolton ratio may offset the smaller expected Bolton ratio resulting from differential proclination of maxillary and mandibular incisors as explained earlier, thus resulting in similar Bolton ratios between our Chinese sample and Bolton's Caucasian sample. Our results suggest that Bolton's original tables for anterior ratios are therefore applicable to the Chinese race and can be used without modification.

CONCLUSION

Odontometric mesio-distal dimensions of anterior teeth indicate that compared to Caucasians, the Chinese teeth were statistically smaller ($p<0.01$) in the maxillary centrals but were larger ($p<0.01$) in the maxillary lateral incisors. No sex differences in mesio-distal crown dimensions were noted except in the maxillary and mandibular canines. No differences were noted in both males and females between antimeres. No statistical difference was noted in the Bolton ratio in our Chinese sample as compared to that of Bolton's, although statistically significant differences at the 1% level were noted in the interfacial angles, overbite and overjet relationships.

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