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A longitudinal study of the mediodistal crown diameters of the deciduous teeth and their permanent successors

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SUMMARY The mediodistal crown diameters of the deciduous teeth and their permanent successors were measured on plaster models of 65 children (34 boys and 31 girls). Correlation analyses were calculated which showed some correlation between the two dentitions. These correlations were stronger in girls than in boys.

On the average the sum of the permanent teeth exceeds that of the deciduous teeth in mediodistal crown diameter but there is considerable individual variation.

Introduction

Many studies have been made of tooth breadth in the deciduous and permanent dentitions from Harris (1839) but until recently they have not been done on the same individuals. Northcroft and Keith (1924) studied the relation between the mediodistal breadths of the upper central incisors in the deciduous and permanent dentitions of 53 children. They found that the breadth of the temporary tooth had a clear correlation with the breadth of the permanent tooth. They gave no figure for the correlation but both measurements and the graph showed it to be distinct. Korkhaus and Neumann (1931) studied the sum of the width of the upper incisors in the deciduous and permanent dentitions and found only an extremely slight correlation and great variations. Jensen *et al.* (1957) published a longitudinal study on 184 North American white children of European stock (91 boys and 93 girls). For about 60 boys and 60 girls they published the correlation coefficients for the mediodistal crown diameters of the deciduous and the corresponding permanent teeth. The highest correlation coefficient was for the maxillary central incisors but there was considerable individual variation for all the teeth. Lysell (1957) measured the mediodistal widths for all the incisors in 75 cases (30 boys and 45 girls) in the deciduous dentition and at 10 years of age. Correlation analyses showed low correlations, the girls' being higher than the boys'. Moorrees (1959) showed similar results.

Material

The material for the present study consisted of plaster casts of the dentitions of 65 children (34 boys and 31 girls) with all deciduous and all permanent teeth present. The material was used by the author in an earlier investigation (Clinch, 1959). The impressions of the deciduous dentitions were made with modelling compound, and those of the permanent dentitions with an alginate material.

Method

The mediodistal crown diameters of the teeth were measured with sliding callipers, the diameters measured were between the contact points in anatomically correct occlusion. Only models where crowding did not make this impossible were used and as there were serial models of each case taken yearly this was not difficult. This analysis is confined to subjects in which all 10 teeth (right and left) were measured in both dentitions. All measurements were made by the author. Ten subjects of each sex had repeat measurements taken on every tooth on separate occasions.

Discussion

The statistical details will be published in a section written by Mr M J R Healy but the salient points can be shown here.

To find the degrees of errors of measurements double determinations were made independently on 10 subjects. These showed no substantial differences between the results for the different teeth and the distribution of the discrepancies between the repeat measurements on each side of the arch is shown in Table 1. Neither mean deviates significantly from zero; the correlation between the discrepancies on the two sides for a given tooth is +0.178 and this correlation, though very small, is significant at the 1 per cent level so that the right side standard deviation is significantly greater than the left side standard deviation. There is no clear explanation of this; it may be relevant that the teeth on the right side were measured before those on the left, but equally it could be due to some inaccuracies in the models.

Lundström (1960) stated that there is no other organ in the body that is so suitable for studying asymmetry as the teeth; firstly because the individual pairs present no problem as regards the axis of symmetry and secondly because their size and shape are determined at an early stage. Therefore,

Table 1 Frequency distribution of discrepancies between repeat measurements on 20 subjects

		Right side							
		–0.3	–0.2	–0.1	0.00	+0.1	+0.2	+0.3 mm	
Left side	–0.2 mm	–	3	1	1	–	–	–	5
	–0.1	–	–	4	19	4	–	–	27
	0.0	1	2	49	239	38	2	1	332
	+0.1	–	–	2	26	8	–	–	36
	+0.2	–	–	–	–	–	–	–	–
		1	5	56	285	50	2	1	400

Right side — Left side

the (right-left) differences for each tooth were calculated and Table 2 gives the standard deviations of these differences. The girls' standard deviations tended to be smaller than the boys' but no other consistent features were present. Lundström (1960) found greater variation in the maxillary lateral incisors and second premolars; our standard deviation for the boys' maxillary lateral incisors is also high (the girls' is less). On the whole, these standard deviations are lower than Lundström's but not to any significant extent. In order to see whether asymmetry in a particular tooth tended to be accompanied by a corresponding or compensating asymmetry elsewhere in the mouth, correlation coefficients between (right-left) differences were worked out for all pairs of teeth in both sexes. But there is little evidence that this occurs. Of more practical interest is the asymmetry in the total breadth of the five teeth. These standard deviations were compared to the values calculated from the individual standard deviations shown in Table 2 on the assumption that no correlation exists between the asymmetries of the different teeth (Table 3). In general the observed values are smaller than expected indicating some compensation in the asymmetries of different teeth in the same jaw and dentition. The differences are, however, small and no such tendency was found in Lundström's material.

The average breadths of the individual teeth and their sex differences are shown in Table 4. With the exception of the maxillary permanent lateral incisors and the second premolars, the boys' teeth were larger than the girls'. This differs from Moorrees who found the boys' teeth invariably larger. The boys maxillary first and second deciduous molars and mandibular deciduous canines were significantly larger at the 5 per cent level; but the most marked difference was in the maxillary and mandibular permanent canines where the boys' teeth were significantly larger at the 1 per cent level. This agrees with Moorrees' findings.

The average breadth variability is shown in Figure. 1 where the standard deviations of the (right and left) average breadths were plotted against the means of the (right and left) average breadths. This showed a tendency for the larger teeth to be more variable in both sexes. It also demonstrated the greater overall variability in the boys.

Table 2 Standard deviations in mm of (right-left) differences, measuring errors eliminated

	Deciduous – Maxilla				
	A	B	C	D	E
Boys	0.144	0.064	0.144	0.166	0.155
Girls	0.078	0.096	0.102	0.068	0.095
	Deciduous – Mandible				
	A	B	C	D	E
Boys	0.118	0.133	0.121	0.118	0.120
Girls	0.142	0.205	0.064	0.122	0.146
	Permanent – maxilla				
	1	2	3	4	5
Boys	0.169	0.204	0.115	0.133	0.087
Girls	0.178	0.144	0.059	0.103	0.083
	Permanent – mandible				
	1	2	3	4	5
Boys	0.110	0.149	0.115	0.129	0.090
Girls	0.068	0.048	0.900	0.105	0.109

Table 3 Standard deviations in mm of (right-left) differences of totals over five teeth-measuring errors eliminated

	Observed			
	Deciduous		Permanent	
	Maxilla	Mandible	Maxilla	Mandible
Boys	0.252	0.255	0.219	0.166
Girls	0.244	0.226	0.221	0.134
	Expected, if individual tooth asymmetries uncorrelated			
Boys	0.312	0.273	0.330	0.269
Girls	0.198	0.320	0.271	0.195

Table 5 shows the mean breadths over the five teeth; in both dentitions the boys' combined measurements were greater than the girls' and in the maxillary deciduous and mandibular permanent teeth this difference was significant at the 5 per cent level. The increase in the total breadth between the deciduous and permanent dentitions was similar in both sexes. The mean value of the combined crown diameters of the permanent teeth is 3.13 mm larger than that of the deciduous teeth in the boys and 3.36 mm in the girls, compared to figures of 5.22 mm and 3.59 mm in Moorrees' series. In the mandible the permanent

Table 4 Mean breadths (right and left sides averaged) in mm. Sex differences with standard errors

		Deciduous - Maxilla			
	A	B	C	D	E
Boys	6.46	5.24	6.78	7.10	8.97
Girls	6.31	5.16	6.61	6.91	8.71
Difference	+. 15 ± .095	+ .08 ± .082	+ .17 ± .115	± .19* ±.093	± .26 ± .124
		Deciduous – mandible			
	A	B	C	D	E
Boys	4.11	4.71	5.82	7.75	9.82
Girls	4.05	4.68	5.57	7.67	9.57
Difference	+ .06 ± .091	+ .03 ± .109	+ .25* ± .107	+ .08 ± .112	+ .25 ± .130
		Permanent – maxilla			
	1	2	3	4	5
Boys	8.86	6.75	8.14	7.10	6.84
Girls	8.72	6.85	7.66	6.96	6.87
Difference	+ .14 ± .137	– .10 ± .143	+ .48** ± .112	+ .14 ±.083	– .03 + .116
		Permanent – mandible			
	1	2	3	4	5
Boys	5.55	6.12	7.08	7.14	7.23
Girls	5.54	6.02	6.70	6.94	7.06
Difference	+ .01 ± .110	+ .10 ± .093	+ .32** + .20	+ .20 ± 103	+ .17 ± .105

*$P < 0.05$; **$P < 0.01$;

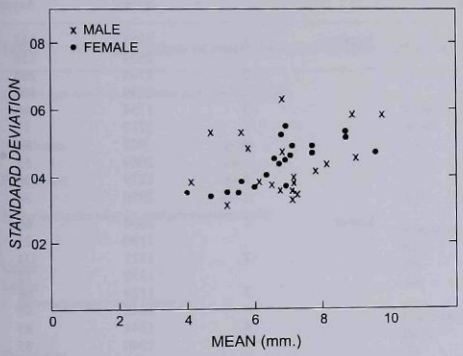

Figure 1 The average breadth variability for the 20 teeth.

Table 5 Mean breadths (right and left sides averaged) in mm. Totals over five teeth, with standard errors

	Maxilla	Mandible
Deciduous, A–E		
Boys	34.56	32.21
Girls	33.70	31.54
Difference	+ 0.86* ± .393	+ 0.67 ± .410
Permanent, 1–5		
Boys	37.69	33.11
Girls	37.06	32.27
Difference	+ 0.63 ± .477	+ 0.84* ± .394
Increase, (Permanent-Deciduous)		
Boys	3.13 (s.d. ± 1.95)	0.90 (s.d. ± 1.50)
Girls	3.36 (s.d. ± 1.38)	0.73 (s.d. ± 1.45)
Difference	– 0.23 ± .368	+ 0.17 ± .401

$P < 0.05$

teeth of the boys are only 0.90 mm larger than the deciduous teeth and in the girls the figure is even less, 0.73 mm. Moorrees' figures were 0.77 and 0.17 mm.

From the orthodontic point of view the main purpose of this study is to find the degree of association between the individual teeth in each dentition and between the sum of the five deciduous teeth and their permanent successors. This can be shown by calculating the correlation coefficient for each tooth and its successor and for the group of teeth and their successors.

Table 8 shows the correlation between the deciduous teeth and the permanent teeth in the same jaw compared to the correlations between the other teeth. There is a slight tendency for the correlation between a deciduous tooth and the permanent tooth which replaces it to be higher than the other coefficients. A summary of the previous figures, Table 9 confirms the slight tendency for a higher correlation between the homologous teeth. More obvious, however, is the sex difference, the boys' coefficients averaging a good deal smaller than the girls particularly in the maxilla, and these differences are statistically significant in both instances.

Results (Section written by M J R Healy)

1. Measuring errors

Ten subjects of each sex had repeat measurements taken on every tooth. There were no substantial differences apparent between the results for the different teeth, and the bi-variate frequency distribution of the 400 pairs of discrepancies on

Table 6 Standard deviations of breadths (right and left sides averaged) in mm

			Deciduous – maxilla			
	A	B	C	D	E	A–E
Boys	0.366	0.310	0.466	0.387	0.452	1.493
Girls	0.398	0.350	0.454	0.367	0.532	1.645
			Deciduous – mandible			
	A	B	C	D	E	A–E
Boys	0.382	0.526	0.476	0.408	0.580	1.833
Girls	0.349	0.340	0.376	0.492	0.466	1.472
			Permanent – maxilla			
	1	2	3	4	5	1–5
Boys	0.576	0.630	0.428	0.328	0.359	1.748
Girls	0.522	0.524	0.474	0.462	0.548	2.067
			Permanent – mandible			
	1	2	3	4	5	1–5
Boys	0.526	0.380	0.350	0.379	0.340	1.433
Girls	0.350	0.368	0.436	0.448	0.492	1.711

Table 7 Variance components ($mm^2 \times 10^4$) due to symmetrically and asymmetrically acting factors

Deciduous					Permanent			
			Sym	Asym			Sym	Asym
Upper	A	Boys	1224	104	Upper	1	3163	143
		Girls	1541	30			2554	158
	B	Boys	928	20		2	3748	208
		Girls	1167	46			2630	104
	C	Boys	2056	104		3	1754	66
		Girls	1997	52			2217	17
	D	Boys	1348	138		4	975	88
		Girls	1312	23			2069	53
	E	Boys	1910	120		5	1239	38
		Girls	2773	45			2956	34
Lower	A	Boys	1377	70	Lower	1	2694	60
		Girls	1106	101			1190	23
	B	Boys	2666	88		2	1321	111
		Girls	933	210			1330	12
	C	Boys	2180	73		3	1139	66
		Girls	1381	20			1848	40
	D	Boys	1583	70		4	1344	83
		Girls	2334	74			1940	55
	E	Boys	3280	72		5	1103	40
		Girls	2053	107			2349	59

the right and left sides is presented in Table 1. Neither mean deviates significantly from zero; the standard deviations of the discrepancies are 0.062 mm on the right side and 0.046 mm on the left, and the correlation between discrepancies on the two sides for a given tooth is +0.178. This correlation, though very small, is significant ($P < 0.001$) and the right side standard deviation is significantly greater than the left side standard deviation ($P < 0.001$). No very clear explanation of these facts presents itself, but it may be relevant that the right hand tooth in each jaw was always measured before the left. The variance of a (right-left) difference is increased by 0.00244 mm^2, and that of a (right + left) average by 0.00086 mm^2, due to measuring errors.

2. Asymmetry

The (right-left) difference was worked out for each tooth and Table 2 gives the standard deviations of these differences. These have been reduced to eliminate the contribution from errors of measurement—they are estimates of the standard deviations that would be obtained if many repeat measurements were made on each tooth and averaged. The girls' standard deviations tend to be smaller than the boys', but no other systematic features are present. Lundström (1960) found greater asymmetry in upper lateral incisor and second premolar than in the other teeth. Our standard deviation for boys' upper lateral incisor is high, but the girls' figure is not outstanding, and in both sexes the upper second

Table 8 Correlation coefficients (effects of asymmetry and measuring errors removed). Figures above the diagonal relate to boys (n=34), those below to girls (n=31)

		Maxilla										Mandible									
		A	B	C	D	E	1	2	3	4	5	A	B	C	D	E	1	2	3	4	5
Maxilla	A	–	.70	.61	.53	.48	.43	.39	.10	.24	.21	.40	.60	.44	.47	.56	.30	.50	.05	.28	.05
	B	.70	–	.43	.55	.43	.33	.17	.07	.02	.27	.28	.43	.44	.53	.54	.21	.40	-.01	.26	.03
	C	.52	.58	–	.31	.37	.09	.03	.18	.21	.08	.27	.65	.69	.35	.49	.08	.18	.19	.29	.12
	D	.59	.65	.58	–	.63	.22	.15	-.01	.02	.24	.34	.32	.42	.39	.50	.27	.30	-.12	.35	.14
	E	.50	.43	.26	.60	–	.16	.06	.02	.23	.45	.28	.33	.33	.33	.67	.18	.04	-.10	.27	.20
	1	.64	.61	.47	.61	.42	–	.64	.54	.40	.30	.40	.45	.24	.12	.43	.70	.76	.26	.50	.41
	2	.53	.48	.42	.44	.47	.61	–	.57	.58	.35	.44	.40	.15	.02	.25	.67	.79	.19	.54	.51
	3	.58	.41	.62	.41	.46	.50	.68	–	.39	.20	.23	.44	.28	-.21	.11	.53	.57	.34	.47	.46
	4	.42	.47	.54	.73	.28	.49	.52	.56	–	.37	.21	.28	.30	.10	.22	.44	.38	.43	.63	.39
	5	.46	.46	.52	.68	.25	.56	.58	.57	.90	–	.17	.10	.17	.31	.44	.25	.25	-.13	.27	.52
Mandible	A	.33	.41	.47	.39	.14	.31	.12	.33	.51	.46	–	.66	.44	.20	.49	.56	.53	.07	.37	.33
	B	.54	.61	.57	.66	.42	.62	.31	.52	.59	.54	.58	–	.67	.26	.48	.56	.58	.20	.31	.26
	C	.48	.46	.51	.41	.14	.36	.12	.34	.38	.33	.47	.55	–	.44	.58	.40	.32	.28	.34	.32
	D	.55	.52	.48	.37	.56	.39	.25	.47	.15	.18	.21	.46	.44	–	.68	.24	.30	.11	.10	.14
	E	.37	.44	.45	.67	.66	.49	.39	.41	.55	.42	.24	.44	.44	.51	–	.54	.35	.20	.39	.39
	1	.55	.35	.34	.68	.30	.62	.39	.31	.65	.66	.19	.43	.20	.08	.50	–	.71	.34	.46	.35
	2	.69	.51	.49	.57	.38	.73	.56	.56	.65	.64	.50	.70	.52	.22	.45	.69	–	.23	.51	.36
	3	.33	.22	.47	.53	.31	.40	.60	.61	.68	.56	.28	.44	.52	.26	.47	.42	.66	–	.41	.16
	4	.35	.28	.39	.39	.40	.44	.51	.66	.59	.44	.20	.48	.13	.15	.40	.36	.56	.61	–	.52
	5	.63	.53	.50	.67	.59	.59	.56	.67	.67	.53	.20	.64	.28	.40	.57	.57	.75	.60	.67	–

Table 9 Averaged values of correlation coefficients. (Effects of asymmetry and measuring errors removed)

a. Between teeth in the same jaw and dentition					
		Adjacent teeth		Others	
		Boys	Girls	Boys	Girls
Deciduous	upper	.54	.62	.50	.50
	lower	.62	.52	.42	.38
Permanent	upper	.50	.72	.41	.53
	lower	.48	.66	.37	.56
b. Between deciduous and permanent teeth					
		Replacements		Others	
		Boys	Girls	Boys	Girls
Upper		.26	.56	.16	.49
Lower		.40	.45	.32	.36
c. Between upper and lower jaw					
		Corresponding teeth		Others	
		Boys	Girls	Boys	Girls
Deciduous		.53	.51	.43	.47
Permanent		.62	.58	.42	.57
d. All other coefficients					
		Corresponding teeth		Others	
		Boys	Girls	Boys	Girls
		.31	.41	.19	.43

premolar is if anything less subject to asymmetry than the other teeth. On the whole, our standard deviations are distinctly less than Lundström.

In order to see whether asymmetry in a particular tooth tended to be accompanied by a corresponding or compensatory asymmetry elsewhere in the mouth, correlation coefficients between (right-left) differences were worked out for all pairs of teeth in both sexes. Out of 190 coefficients for each sex, 19 were significant at the 5 per cent level for boys (13 –ve, 6 +ve) and 16 for girls (9 –ve, 7 +ve). Only one coefficient was significant in both sexes — this was between upper central insisor and canine and was negative.

Of more practical interest is the asymmetry in the total breadth of the five teeth. The standard deviations of the (right-left) differences of this quantity are shown in Table 3, together with 'expected' values calculated from the individual standard deviations in Table 2 on the assumption of no correlation between the asymmetries of different teeth. In general, the observed values are smaller than those expected, indicating a certain amount of compensation in the asymmetries of different teeth in the same jaw and dentition.

3. Average breadths - mean values

The remainder of this section deals with the average measurements of corresponding right and left teeth. The means of these are given in Table 4, together with the average sex differences, while Table 5 relates to the sums of the measurements over the five teeth. There is a general tendency for the boys' teeth to be broader than the girls', especially the permanent canine. As the permanent teeth replace the deciduous teeth, the total breadth increases noticeably in the upper jaw, while the increase in the lower jaw is small on average; the two sexes agree closely in this respect.

4. Average breadths - variability

The standard deviations of the (right + left) average breadths are given in Table 6. Plotting the standard deviations against the means (Fig. 1) shows a tendency for the larger teeth to be the more variable, but there is no marked sex difference in variability.

A measurement on a single tooth may be thought of as made up of three independent parts:

1. An amount characteristic of the individual subject (tooth).
2. A deviation from this amount which is different for the right and left hand teeth.
3. A measuring error.

The relative sizes of the variances of the first and second of these can be judged from Table 7. The 'asymmetric variance' averages about 5 per cent of the 'symmetric variance' for boys and about 3 per cent for girls. This table may be compared with the results of Lundström (1960).

5. Average breadths - correlations

The correlation coefficients between every pair of teeth are presented in Table 8. These are 'between-subject' correlations, adjusted to allow for the attenuating effects of asymmetrically-acting factors and measuring errors (Healy, 1958). This large table is not easily comprehensible, and more meaningful average values of the correlations are given in Table 9. These averages have in fact been calculated by transforming the correlations to z-values averaging these and transforming back.

As might be expected, all the average correlations (and almost all the individual values) are positive. There is a definite tendency for the correlations between corresponding teeth, whether in different jaws, different dentitions or both, to exceed the other correlations of the same kind; also, correlations between adjacent teeth tend slightly to exceed those between non-adjacent teeth. The boys' correlations are generally somewhat lower than the girls', particularly those between permanent and deciduous teeth.

Conclusions

The investigation shows that the degree of association between the mediodistal crown diameters of the deciduous and permanent teeth in an individual is not marked although it tends to be higher than the coefficients between the other teeth. In general small deciduous teeth will be replaced by small permanent teeth and large deciduous teeth will be replaced by large permanent teeth. But the relatively low numerical values of the correlation coefficients indicate considerable individual variation. The highest correlation coefficient was found for the mediodistal crown diameter of the deciduous and permanent maxillary central incisor (+ .42 in boys and + .62 in girls) and even in this instance no accurate prediction can be made concerning the diameter of the permanent teeth based on the measurement of the deciduous predecessor.

In this series the fact that the girls' correlations are considerably higher than the boys' is obvious but larger numbers would be needed to prove this was more than a trend. However some weight can be given to the observation as both Moorrees and Lysell found the same tendency. In fact Lysell (1957) has pointed out that this could explain the discrepancy between the results of Northcroft and Keith (1924) and Korkhaus and Neumann (1931). Both series comprised 53 children with no stated sex distribution; if the girls were in the majority in the former series and the boys in the latter this could explain why Northcroft and Keith (1924) found a distinct correlation and Korkhaus and Neumann (1931) an extremely slight correlation. The largest sex difference between the size of the teeth is shown in the permanent canines; these teeth also show the largest sex difference in time of eruption averaging eleven months earlier in girls (Clements *et al.*, 1953).

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