Compensatory developmental interactions in the size of permanent teeth in three contemporary populations

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In a symposium on genetics, Bailit[1] in 1975 stated, "the seemingly minor difference in dental traits among and within populations can be of great interest and importance to both anthropologists and practicing dentists. For anthropologists, these differences reflect the ongoing process of evolution and provide a method for studying evolutionary mechanics. For dentists these differences represent the variation that must be considered in the daily care of patients."

Variation in tooth size is influenced by genetic and environmental factors.[1] Some of the factors which contribute to the variability of permanent tooth size are: race,[2,3] sex,[2] heredity,[4] environment,[5] secular changes,[6] and bilateral asymmetry.[7,8] Environmental variables such as nutrition, disease or climate affect the dentition during the prenatal period, but seem to have little influence on normal dental variation.[1]

The genetic basis for this variation is best explained by a polygenic model of inheritance. In 1964 Lundström[9] compared 97 pairs of same-sex monozygotic and dizygotic twins and found a stronger correlation in mesio-distal tooth diameter between monozygotic twins. He concluded that tooth size is determined to a large extent by genetic factors.

It is generally agreed that there is a reduction in the size of the jaws during hominid evolution, accompanied by a reduction in tooth size.[10,11] It has also been postulated that this reduction in tooth size is not evenly distributed on the dentition, but results in compensatory tooth size interactions between early and late developing teeth within the same morphologic tooth class.[12,13] A morphologic tooth class can be comprised of either incisors, premolars or molars. A number of investigators have demonstrated such compensatory interactions between the teeth. Sofaer et al,[13] observed an increase in the size of the maxillary central incisors adjacent to congenitally missing lateral incisors, but this increase in size was not observed when the lat-

Abstract

The purpose of this study was to determine whether developmental interactions exist between the mesio-distal diameters of the first and second developing teeth in each of two morphologic tooth classes. The interactions were evaluated for the maxillary and mandibular incisors and premolars. Measurements were obtained on the dentitions of three contemporary samples from Iowa, Egypt and Northern Mexico.

The findings from this study indicate that developmental interactions are present in the mesio-distal diameters between the first and second developing teeth within the two morphologic tooth classes evaluated, namely incisors and premolars. In other words, the mesio-distal diameter of the first developing tooth significantly influences the size of the second developing tooth within the same morphologic class. This manuscript was originally submitted November 1988.

Key Words

Mesio-distal tooth size • Developmental interactions

eral incisor was peg-shaped. Garn and Lewis[14] also found an increase in the size of the first permanent molars in individuals with missing third molars.

Kieser, et al,[15] on the other hand, observed a strong positive correlation between the mesio-distal and buccolingual diameters of the first and second formed tooth within each morphologic class i.e. when the first molar, first premolar and central incisor were larger or smaller than average size, the second molar, second premolar and lateral incisor expressed the same trend. Kieser et al. were unable to demonstrate compensatory tooth size interactions between the first and second developing tooth when the sizes of the teeth were compared, even after correction for variations in arch length.[15]

The literature review indicates there is still lack of agreement regarding the presence of compensatory interaction between the first and second developing teeth in each morphologic tooth class.

Purpose of study

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Materials and methods

The criteria for selecting the subjects and dental casts were as follows:

1) An "acceptable" dento-facial relationship i.e. a Class I molar and canine relationship, with zero to four millimeters of incisor crowding, no congenitally missing teeth, no apparent skeletal discrepancies, no congenital craniofacial abnormalities, and no history of orthodontic treament.
2) Fully erupted permanent incisors, canines and premolars on both sides of the maxillary and mandibular dental arches. All teeth were assessed to be morphologically normal. Casts with gross dental abnormalities, apparent loss of tooth substance due to attrition, caries, or restorations which could affect the mesio-distal crown diameter were rejected.

Of 500 Egyptian school children examined clinically in Alexandria, 54 subjects, 32 males and 22 females, met the above criteria. The age for the male and female subjects ranged between 12.0 and 14.0 years, with a mean age of 12.6 years for both groups.

Approximately 700 boys and girls were examined in two junior high schools in Chihuahua, Mexico. Geographically, one school is located in the northeast and the other in the southwest parts of the city, to include students from various socio-economic backgrounds. Twenty-six males and 34 females met the selection criteria. The mean age for the males and females were 12.5 and 12.9 years, respectively. The genetic pool in the Chihuahua population can be assumed to be mainly an admixture of Spanish (Caucasian) and North American Indian (Mongolian) descent.

The Iowa measurements were obtained from plaster casts obtained on 33 males and 22 females enrolled in the Facial Growth Study at the University of Iowa. The subjects had a mean age of 13.8 and 14.2 years, respectively. All participants were Caucasians, lived in or around Iowa City and 97 percent were of Northern European ancestry.

Measurements were made directly on unsoaped dental casts. The accuracy of plaster casts fabricated from alginate impressions as a representation of actual tooth size was investigated by Hunter and Preist[3] and Kellam.[16] They concluded that measurements made on dental casts are more reliable than those made directly in the mouth.

The measurement procedures of the mesio-distal tooth diameters were performed as described by Hunter and Priest[3] and Kellam.[16] The greatest mesio-distal measurement from anatomic mesial contact point to the anatomic distal contact point was taken to the nearest 0.01 millimeter, using pointed calipers.

Two investigators independently recorded double measurements for each measurement. Intra- and inter-examiner reliability were predetermined at 0.05 millimeters. Discrepancies greater than this limit necessitated a new set of measurements and the nearest three measurements were averaged.

Statistical analysis

1. Identification of "large" and "small" first developing teeth within each population:

In previous studies, all the teeth within a morphologic class were evaluated for compensatory developmental interactions. This approach produced conflicting results.[13-15] On the other hand, it can be reasonably assumed that if such interactions are present, they should be more influential and apparent at the extremes of the sample distribution, i.e. with the largest and smallest first developing teeth.

To identify the "large" and "small" first developing teeth in the two morphologic classes eval-

Table 1
Descriptive statistics (in percent) and results of paired *t*-tests for the comparisons between the ratios of two groups with "small" and "large" first developing teeth from a combined sample derived from three different populations.

Table 1

		MALES				FEMALES			
		N	**x̄**	**SD**	**Sig.**	**N**	**x̄**	**SD**	**Sig.**
	Maxillary I_1/I_2								
Right	S	26	126.1	8.4	.03	27	129.0	12.9	.76
	L	35	130.3	6.1		27	129.0	10.8	
Left	S	27	127.1	10.0	.04	27	129.9	10.2	.53
	L	32	132.1	8.5		28	131.7	11.6	
	Mandibular I_1/I_2								
Right	S	28	88.7	4.3	.003	26	88.5	3.8	.0001
	L	30	92.7	5.8		29	93.6	4.2	
Left	S	26	99.0	4.6	.03	27	89.8	4.5	.0008
	L	35	92.5	4.1		31	94.1	4.9	
	Maxillary PM_1/PM_2								
Right	S	29	101.4	4.5	.006	24	100.3	4.9	.002
	L	35	105.3	6.8		29	104.7	5.1	
Left	S	28	101.4	6.0	.0001	27	99.5	8.2	.01
	L	32	107.9	5.8		24	104.5	5.8	
	Mandibular PM_1/PM_2								
Right	S	31	95.7	6.0	.03	27	95.3	4.5	.0006
	L	32	98.6	4.2		29	99.9	4.9	
Left	S	29	95.3	5.1	.002	26	96.2	5.3	.005
	L	29	99.1	3.5		29	100.4	5.2	

N = Sample Size **x̄** = Mean **SD** = Standard Deviation **Sig.** = Level of Significance
I_1 = Central incisor **I_2** = Lateral incisor **PM_1** = First premolar **PM_2** = **Second premolar**
S = Group with "small" first developing tooth **L** = Group with "large" first developing tooth

uated, the distribution for the maxillary and mandibular central incisors and first premolars were examined for each of the three populations, for males and females as well as for the right and left sides separately.

Teeth with larger and smaller mesio-distal diameters were identified and the middle one-third dropped. Within each morphologic tooth class, the ratio of the first to the second developing tooth was calculated, i.e. the ratio of the central to the lateral incisor and the ratio of the first to the second premolar.

As a result, for each of the three populations, the following subgroups were identified: large and small; maxillary and mandibular; right and left; incisors and premolars.

2. Comparisons between populations:

When these subgroups were identified for each population, their sample size varied between a minimum of six and a maximum of 15 subjects. The analysis of variance, general linear models procedure (GLM), was used to compare the corresponding ratios from the same morphologic class between the three populations, for males and females, as well as for the right and left sides separately.

F-values were calculated and when significant at $P<0.05$, the Duncan's Multiple Range Test was used to compare each mean with every other mean. The Duncan's test was used to further pinpoint group differences found in the GLM analysis. Of 32 comparisons, only one was significantly different at the .05 level of confidence. As a result, it was concluded that combining similar morphologic tooth classes from the three samples is appropriate.

3. Comparisons of the ratios of the "large" and "small" teeth:

With the identification of the "large" and "small" first developing teeth for each morphologic class, the ratio of the first to the second developing teeth were calculated. The mean, standard deviation, standard error and minimum and maximum values were computed for each of the ratios in each morphologic class for the three populations combined.

Student's *t*-tests were then used to compare the ratios of the "small" and "large" first developing tooth in each morphologic tooth class. Significance was predetermined at the .05 level of confidence.

Findings

The means and standard deviations for the ratios of the first to the second developing teeth, for both males and females, for the right and left sides and for each morphologic tooth class, namely incisors and premolars, in the maxilla and mandible are presented in Table 1. In order to simplify the interpretation of the data, the ratios were converted into percentages.

As stated earlier, the results of the analysis of variance allowed combining the same morphologic tooth class from the three populations, increasing the sample size to between 24 and 35 subjects in the various incisor and premolar subgroups.

The results of the *t*-test comparisons indicated that, in general, the ratios of the first and second developing teeth in the "small" and "large" subgroups, are significantly different (Table 1). Specifically, the results indicated that individuals in the group with the "large" first developing tooth had a relatively smaller secondary developing tooth when compared to the corresponding ratio for the "small" subgroup. One exception to these findings is the comparisons of the ratios for the maxillary incisors in females.

Discussion and conclusions

Dentists in general and orthodontists in particular are cognizant of variation in the size of teeth and how these differences can influence a number of clinical restorative and orthodontic procedures. As a result, it is essential to have a better understanding of the different processes that interplay to influence the variations in the size of the overall dentition as well as the variation between the teeth within a single arch.

In the present investigation, the developmental interactions between the central and lateral incisors as well as the first and second premolars were evaluated. It was not possible to test the same hypothesis for the permanent molar tooth class because in a significant number of the cases the second molars did not erupt sufficiently to permit accurate measurements of their mesio-distal diameters.

The findings from this study indicate that developmental interactions are present in the mesio-distal diameters between the first and second developing teeth within the two morphologic tooth classes evaluated, namely incisors and premolars. In other words, the mesiodistal diameter of the first developing tooth significantly influences the size of the second developing tooth within the same morphologic class. Therefore, if the first developing tooth is large, the second developing tooth will be relatively small. These findings support previous observations by Garn and Lewis[14] and Sofaer et al[13] on the changes in the size of the teeth that are near a congenitally missing unit, within the same morphologic class. The present findings further indicate that these interactions occur even when the teeth were not congenitally missing.

These developmental interactions were consistent for all the morphologic tooth classes evaluated in the maxilla and mandible and for both males and females, with one exception — the interaction between the maxillary central and lateral incisors in females (Table 1). Such a finding can be explained by further evaluation of the data, which points to the significantly large standard deviations for the ratios within the maxillary incisors morphologic tooth class. This is to be expected, since the maxillary lateral incisors vary significantly in their mesio-distal diameters in both sexes, but particularly so in females.

Finally, it needs to be emphasized that the presence of these developmental interactions does not supercede the fact that in individuals with large or small dental arches, the teeth in general will exhibit a corresponding increase or decrease in their mesio-distal diameters.

Therefore, it can be concluded that the presence of a positive correlation between oversized or undersized early developing teeth and their later developing neighbors does not preclude the possibility of an accompanying negative interaction between the same teeth. In other words, the two neighboring teeth within a morphologic tooth class can both be oversized, but the first developing tooth is more so than the second.

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