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# CAUSAL FACTORS FOR INTERDENTAL SPACES IN THE CANINE REGIONS OF INFANTILE TWINS

BY

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## ABSTRACT

Examinations on causal factors for interdental spaces in the deciduous canine regions were made mainly by the twin method. Observations on the interdental space and dental arch at the age of 4 years: It was found that (1) the source for variation in the size of precanine space was due to the tooth size and dental arch size, and that of postcanine space was due to the tooth size, and that (2) genetic factors were small for variation in interdental space, though genetic factors were large for variations in tooth size and dental arch size. These results possibly suggest that genetic factors for variation in tooth size and dental arch size are independent and would be regarded as being a part of environmental factors for variation in interdental space.

## INTRODUCTION

There have been many arguments on the physiological role of interdental spaces on the deciduous dentition which may contribute to the normal occlusion and alignment of the permanent dentition[1–11].

The interdental spaces do not develop or change in size during the period from complete eruption of the deciduous teeth to the emergence of mandibular permanent central incisor or first molar[7,12].

Baume[7] has classified the deciduous dentition into two types; the one with interdental spaces or spaced type and the other without interdental spaces or closed type. In various types of interdental spaces, the precanine spaces in the maxillary arch and the postcanine spaces in the mandibular arch termed primate spaces are found in over 70 per cent of deciduous dentition[3–5] and are one of the features in the deciduous dentition[6–8].

It has been considered that the interdental spaces in the deciduous dentition arise from a disproportion between tooth size and dental arch size[7,11]. On the other hand, Korkhaus[19], Goldberg[20], and Newton[21] suggested that the occurrence of interdental spaces might be genetically determined.

There have been many discussions on the genetic factors for the mor-

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phological variation in the tooth and jaw separately[22–28]. However, there have been few investigations on the genetic contribution to the complex whole of tooth and jaw because there are many methodological difficulties. As it is generally believed that the interdental spaces are due to the relationship between the teeth and alveolar bone which is part of jaws, it would not be thought that there are any genetic factors which directly contribute to the interdental spaces. Yet, it may be possible to detect causal factors for interdental space by a genetic method, because the interdental spaces can be regarded as a metric trait.

In a metric trait, it is conceivable that phenotypic variation is due to genetic and environmental factors. According to the method of quantitative genetics, the amount of variation is expressed as the variance, and then the phenotypic variance is partitioned into genetic and environmental components. Partition of the variance can also formulate the relative importance of genotype and environment in determining the phenotypic variation. Theoretical basis and analytical methods on the relative importance have been discussed by many workers[29–33].

The comparison between monozygotic and dizygotic twins has been considered to be an efficient approach for estimating the relative importance of genotypic and environmental factors for variation of a metric trait, though this method has been criticized[30,32–39].

In order to provide more informations on the causal factors for interdental spaces in the deciduous dentition, a study was made to investigate in particular;

1) the extent to which the size of interdental space is influenced by tooth and dental arch size,

2) the relative importance of genetic and environmental factors for variation in the interdental space and dental arch in the deciduous dentition.

## Materials and Methods

*Materials*

In the present analysis, a part of the materials which were examined and accumulated by the staff of the Department of Pedodontics, Tokyo Medical and Dental University, for a series of genetic studies of twins was used.

As was described by Asano[24] and Nakata[40], the materials were obtained from 120 pairs of Japanese twins who were born at six major maternity hospitals in Tokyo since 1958. The criteria for their selection were health condition and availability for participation in the program.

The examinations of twins were made every six months beginning from their second or third birthday, and the oral and radiological (dental radiographs and cephalometric radiographs) examinations were carried out and dental casts were also obtained.

The zygosity diagnoses of the twins were made mainly on the basis of serological evidences.

The dental casts which were prepared from alginate impressions by the routine method around the birthday of each age from 28 pairs of twins (11 male and 7 female pairs of monozygotic twins, and 10 male pairs of dizygotic twins) born during 1958 to 1964 were used for measuring the interdental spaces (in the age range of 4 to 6 years) and the dental arches (in the age range of 4 to 8 years).

The criteria for selecting the dental casts were as follows: (1) There were no defective crowns from caries, complete dentition without abnormality, and (2) there were no malocclusions such as cross bite, severe crowding, etc.

*Measurements*

*1) Interdental spaces*

The maxillary and mandibular interdental spaces between the deciduous lateral incisor and the deciduous canine (precanine space), and between the deciduous cane and the first deciduous molar (postcanine space) were measured on both sides of jaw.

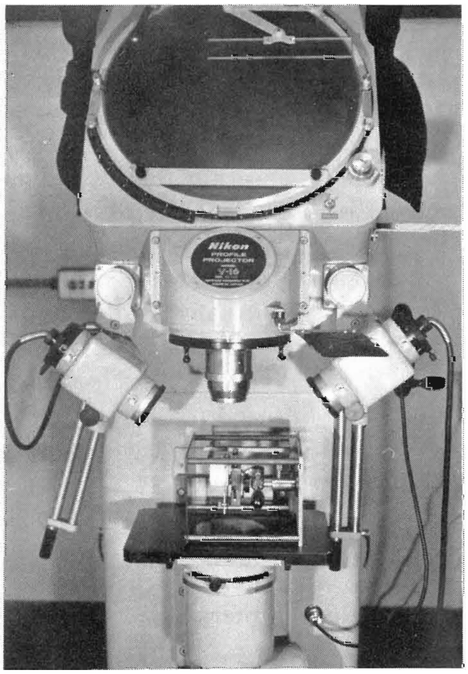


Fig. 1. An apparatus and optical comparator used to measure the interdental space.

The basal plane of the dental cast was made parallel to the occlusal plane of the deciduous dentition (in the present observations, the term, occlusal plane, may refer to that which will be determined when the side of the cusps of the dental cast was placed on the flat plane). Each dental cast was placed on the apparatus which enables it to be rotated around the axis vertical to the occlusal plane. The apparatus with the dental cast was then placed on the stage of an optical comparator (Nippon Kogaku K.K., type V-16 (Fig. 1)). The narrowest part of the interdental space parallel to the occlusal plane was measured from the labial side of the teeth in incident light. The measurement was made with the use of a scale graduated to 0.4 mm. Magnification of the optical comparator was five times.

*2) Dental arch size (intercanine distance and arch circumference)*

The width between the left and right centers of the lingual cinguli of the deciduous canine at the gingival margin was measured with the use of a sliding caliper graduated to 0.05 mm. That width was regarded as the intercanine distance.

To measure the length of the circumference, three points were selected; the lowest (in the mandible) or th highest (in the maxilla) points of the buccal gingival margins of the left and right first deciduous molars, and the middle point of the line extending between the lowest (in the mandible) or the highest (in the maxilla) points of the lingual gingival margins of the left and right deciduous incisors. A thin nichrome wire (0.16 mm in diameter) was extended over these three points of the dental cast. The positions of the two points of the left and right first deciduous molars were marked on the nichrome wire and then the distance was measured on a straight wire by the sliding caliper. That distance was regarded as the circumference of the dentition between the left and right first deciduous molars.

*3) Tooth size*

Tooth size (deciduous lateral incisor, deciduous canine, and first deciduous molar) is the mesiodistal crown diameter of the tooth. These measurements have already been made by Asano[24] from the same individuals used in the present study.

*4) Measurement errors*

In each dental cast, the measurement was made twice at a sufficient time interval to assess the error of measurements.

## The Method of Analysis

To detect the causal factors of interdental spaces in deciduous dentition, following analyses were made.

1. The extent to which the interdental space was affected by the tooth size and/or the dental arch size was evaluated from the correlations between

interdental space and tooth size, and between interdental space and dental arch size.

2. The relative importance of genetic and environmental factors for variation in interdental space and in dental arch size was estimated by the twin method.

*1) Correlation between interdental space and tooth size, and between interdental space and dental arch*

The size of interdental spaces would be affected by that of tooth and of dental arch. The relationship between the interdental space and the tooth size, and between interdental space and dental arch size can be estimated from their correlations.

Estimation is first made on simple correlations between the interdental spaces (precanine and postcanine space) and the dental arches (intercanine distance and arch circumference), and between interdental spaces and the deciduous tooth sizes (the combined mesiodistal crown diameters of lateral incisor and canine, and those of canine and first molar). However, the effect of tooth size in estimating the simple correlation between interdental spaces and dental arches cannot be disregarded, and the effect of dental arches in estimating that between interdental spaces and tooth sizes cannot also be disregarded.

Therefore, the simple correlation does not seem to represent solely the relationship between the two. To exclude the effect of tooth size in estimating the correlation between interdental space and dental arch, and of the dental arch in estimating that between interdental space and tooth size, partial correlations were calculated by assuming the tooth size and dental arch to be constant.

*2) Analysis of twin data*

The twin study method is based on the fact that the two types of twins differ genetically, the monozygotic twins having identical genotypes and the dizygotic twins having only the same degree of genetical similarity as do ordinary fully siblings. Therefore, it is assumed that the difference between the two members of a monozygotic twin pair is due to an environmental influence, while that between the two members of a dizygotic twin pair is due to both their different genetic constitutions and the environmental influence. The method also depends on the assumption that the average environmental differences for dizygotic twins and for monozygotic twins are the same, though this assumption has some criticisms. Then it would be possible to estimate the genetic factor for variation in human metric traits by comparing the amount of difference between monozygotic twins with that between dizygotic twins.

(*a*) *Analysis of variance*

The interdental space is measured quantitatively, that is, as a metric trait, and then it would be possible to estimate the relative importance of the genetic and environmental factors of variation for interdental space by the analysis of variance of the measurements. In many methods to estimate the relative importance, it seems that the method described by Osborne and De George[33] is most efficient and applicable, and the method was used in the present study. Its statistical formulae are shown in Table 1.

*The mean intrapair variance* enables estimation of the degree of relationship between the measurements of members of twin pairs. If genetical influence on the interdental space and dental arch is large, the mean intrapair variance should be smaller for monozygotic twins, having all genes in common, than for dizygotic twins, having on the average only half of their genes in common. Then, comparison of mean intrapair variance of monozygotic and dizygotic twins will enable estimation of the genetic factors for variation of a metric trait. In monozygotic twins, the observed difference between the members of twin pairs is due to the measurement error and the environmental factor, and it would therefore be expected always to provide a large variance than measurement error.

*The mean interpair variance* is calculated from the averages of the measurements for the two members of each pair of twins and expresses the variation found in genetically unrelated individuals. If genetical influence on the interdental space and dental arch is large, the mean intrapair variance should be smaller than the corresponding mean interpair variance.

The comparison between mean intrapair variance of monozygotic twins [V(MZ)] and that of dizygotic twins [V(DZ)] provides a conventional and useful test for genetic factors of variation. Absence of statistical significance in this ratio [V(MZ):V(DZ)] could be due to either large environmental factors or small genetic factors of variation between dizygotic co-twins. Both the ratios between variance of measurement error [V(ME)] and mean intra-

Table 1. Statistical formulae for twin analysis

| | |
|---|---|
| Mean intrapair variance [V(MZ)], [V(DZ)] | $=\dfrac{\Sigma(x_{i1}-x_{i2})^2}{2n}$ |
| Mean interpair variance [V(IP)] | $=\dfrac{2\Sigma\left(\frac{x_{i1}+x_{i2}}{2}-m\right)^2}{n-1}$ |
| n=Number of twin pairs<br>$x_{i1}$, $x_{i2}$=Individual measurements of members of twin pairs<br>m=Mean of all observations | |
| Variance of measurement error [V(ME)] | $=\dfrac{\Sigma(x_{i1}-x_{i2})^2}{2n}$ |
| $n$=Number of casts<br>$x_{i1}$, $x_{i2}$=First and second measurements | |

pair variance of monozygotic twins [V(MZ)], and between mean intrapair variance [V(DZ)] and interpair variance [V(IP)] of dizygotic twins can then be used to help interpret the ratio between [V(MZ)] and [V(DZ)]. The variance ratios were tested by the F-test.

(*b*) *Heritability estimates*

Phenotypic variance [V(P)] in a metric trait is the sum of the components, that is, genotypic variance [V(G)] and environmental variance [V(E)], and the formula is as follows:

$$V(P)=V(G)+V(E)$$

Heritability is defined as the proportion of genotypic variance to the phenotypic variance in a metric trait. It is one of the methods for appraising the relative importance of genetic and environmental factors for a metric trait, and makes it possible to express the relative importance briefly. The formulation of heritability which has been used in twin study is as follows:[31,32,41]

$$\text{Hertability (H)}=\frac{V(DZ)-V(MZ)}{V(DZ)}=\frac{V(G)}{V(P)}$$

where V(DZ) and V(MZ) are the mean intrapair variance of dizygotic and monozygotic twins, respectively.

## RESULTS

Tables 2, 3a, and 3b show the mean values for the various measurements of interdental spaces and dental arches in male and female twin pairs, together with the standard error of the means. Prior to the final analysis, several basic examinations were made as follows.

*a*) *Effect of birth order*: The difference of the means was examined by the *t*-test between members of twin pairs classified by birth order, that is, between elder co-twin group [A] and younger co-twin group [B]. However, significant difference was not found, and the fact indicates that it was impossible to recognize the difference in values between members of a twin pair.

*b*) *Difference between left and right sides of dentition*: Using the elder co-twin group [A], comparisons were also made between left and right sides of the deciduous dentition. There was no significant difference.

*c*) *Sex difference*: Similar comparisons were also made between male and female monozygotic twin groups. Since it was found that there was no effect of birth order, only elder co-twin group [A] was used for comparison. Significant differences were found in precanine spaces of maxillary dentition in all age groups ($p<0.05$) and in precanine spaces of mandibular dentition in a six-year group ($p<0.05$), and in postcanine spaces of maxillary and mandibular dentition in a six-year group ($p<0.05$). No significant difference was found in other measurements.

Table 2. Measurement of interdental spaces

| | Age (years) | Precanine space [A] Mean±S.E. (×0.01 mm) | Precanine space [B] Mean±S.E. (×0.01 mm) | Postcanine space [A] Mean±S.E. (×0.01 mm) | Postcanine space [B] Mean±S.E. (×0.01 mm) |
|---|---|---|---|---|---|
| MZ (male, 11 pairs) | | | | | |
| Maxilla | 4 | 117±13 | 118±15 | 60±13 | 60±11 |
| | 5 | 115±14 | 115±13 | 65±15 | 60±11 |
| | 6 | 110±15 | 114±15 | 52±12 | 50± 9 |
| Mandible | 4 | 43±11 | 55±11 | 42± 8 | 34±11 |
| | 5 | 44±10 | 60±11 | 39± 9 | 32±11 |
| | 6 | 43±11 | 49± 9 | 29± 8 | 31± 9 |
| DZ (male, 10 pairs) | | | | | |
| Maxilla | 4 | 58±15 | 83±16 | 65±10 | 71± 9 |
| Mandible | 4 | 44±11 | 24± 9 | 41± 9 | 35±16 |
| MZ (female, 7 pairs) | | | | | |
| Maxilla | 4 | 55±21 | 62±26 | 33±23 | 49±24 |
| | 5 | 48±21 | 58±26 | 23±14 | 38±16 |
| | 6 | 41±22 | 54±20 | 10± 7 | 22±12 |
| Mandible | 4 | 25±10 | 22±12 | 39±17 | 34±10 |
| | 5 | 21± 9 | 17±10 | 32±16 | 25±11 |
| | 6 | 6± 5 | 9± 5 | 16± 9 | 7± 5 |

[A] Elder co-twin group, [B] Younger co-twin group.

Table 3a. Measurement of dental arches

| | Age (years) | Intercaine Distance [A] Mean±S.E. (×0.01 mm) | Intercaine Distance [B] Mean±S.E. (×0.01 mm) | Arch Circumference [A] Mean±S.E. (×0.01 mm) | Arch Circumference [B] Mean±S.E. (×0.01 mm) |
|---|---|---|---|---|---|
| MZ (male, 11 pairs) | | | | | |
| Maxilla | 4 | 2441±31 | 2489±32 | 4596± 54 | 4652± 55 |
| | 5 | 2490±30 | 2521±34 | 4606± 53 | 4639± 56 |
| | 6 | 2527±36 | 2570±39 | 4592± 59 | 4665± 69 |
| | 7 | 2572±41 | 2631±56 | 4673± 88 | 4740±106 |
| | 8 | 2686±52 | 2710±59 | 4866±123 | 4897±139 |
| Mandible | 4 | 1855±27 | 1880±26 | 3488± 50 | 3547± 39 |
| | 5 | 1867±28 | 1899±18 | 3489± 46 | 3549± 34 |
| | 6 | 1893±29 | 1936±25 | 3522± 63 | 3575± 49 |
| | 7 | 1987±39 | 2030±31 | 3634± 75 | 3693± 70 |
| | 8 | 2087±48 | 2101±33 | 3748± 79 | 3806± 62 |
| DZ (male, 10 pairs) | | | | | |
| Maxilla | 4 | 2343±47 | 2404±36 | 4475± 81 | 4543± 53 |
| Mandible | 4 | 1790±62 | 1854±41 | 3487± 86 | 3553± 45 |

[A] Elder co-twin group, [B] Younger co-twin group.

Table 3b. Measurement of dental arches

| | Age (years) | Intercanine Distance [A] Mean±S.E. (×0.01 mm) | Intercanine Distance [B] Mean±S.E. (×0.01 mm) | Arch Circumference [A] Mean±S.E. (×0.01 mm) | Arch Circumference [B] Mean±S.E. (×0.01 mm) |
|---|---|---|---|---|---|
| MZ (female, 7 pairs) | | | | | |
| Maxilla | 4 | 2353±37 | 2376±52 | 4560±68 | 4616± 98 |
| | 5 | 2350±44 | 2377±55 | 4525±56 | 4595± 95 |
| | 6 | 2369±46 | 2390±55 | 4483±59 | 4561± 93 |
| | 7 | 2463±62 | 2481±77 | 4540±72 | 4644±109 |
| | 8 | 2628±80 | 2662±93 | 4820±90 | 4904±119 |
| Mandible | 4 | 1798±41 | 1821±55 | 3559±82 | 3580± 76 |
| | 5 | 1815±39 | 1819±44 | 3542±82 | 3571± 73 |
| | 6 | 1851±45 | 1869±51 | 3578±60 | 3614± 59 |
| | 7 | 1987±66 | 1961±67 | 3734±62 | 3755± 73 |
| | 8 | 2153±61 | 2085±86 | 3858±48 | 3863± 97 |

[A] Elder co-twin group, [B] Younger co-twin group.

*d) Age difference*: To estimate the relative importance of the genetic and environmental factors for variation in interdental space and dental arch at different ages, an attempt was made to examine twin materials by longitudinal observation. However, available dental casts of dizygotic twins were too few to obtain those of different ages, because of dental caries and for other reasons. It was possible to estimate the relative importance of the genetic and environmental factors for variation in interdental space and dental arch only at the age of 4 years. The measurements in male and female monozygotic twins at different ages are shown in Tables 2, 3a, and 3b.

The developmental changes in interdental space and dental arch size in male and female monozygotic twins were estimated from the correlations between interdental space and age (during 4 to 6 years), and between dental arch size and age (during 4 to 8 years). The changes in intrapair difference for interdental space and dental arch size, which is expressed as the absolute value of difference between the members of monozygotic twins, were also estimated from the correlations between intrapair difference and age.

Table 4 shows the simple correlation between interdental spaces, dental arches, or their intrapair difference and age. Since it has been said that the size of interdental spaces and dental arches was fairly constant from 3 to 6 years in the deciduous dentition[7,12], the range of ages was divided into two groups, from 4 to 6 years and from 6 to 8 years. The observed correlation coefficients were tested for any significant difference from zero.

In 4-to-6-year group, the correlation coefficients (shown in parentheses in Table 4) in both in interdental space and dental arch were not significantly different from zero, and the fact indicates that the change in size of interdental space and dental arch did not occur during 4 to 6 years of age.

Table 4. Correlation coefficients between intrapair differences and the ages, between interdental spaces and the ages and between dental arches and the ages

| | | Age range (4∼6 years) Male | Female | Age range (6∼8 years) Male | Female |
|---|---|---|---|---|---|
| Interdental space | | | | | |
| Precanine | | | | | |
| space | Maxilla | −0.105 | 0.077 | — | — |
| | | (0.000) | (−0.100) | — | — |
| | Mandible | −0.092 | −0.236 | — | — |
| | | (0.000) | (−0.374) | — | — |
| Postcanine | | | | | |
| space | Maxilla | 0.000 | −0.031 | — | — |
| | | (−0.100) | (−0.245) | — | — |
| | Mandible | −0.161 | −0.119 | — | — |
| | | (0.141) | (−0.265) | — | — |
| Dental arch | | | | | |
| Intercanine | | | | | |
| distance | Maxilla | 0.051 | −0.369 | −0.169 | 0.244 |
| | | (0.324) | (0.017) | (0.427*) | (0.574**) |
| | Mandible | 0.246 | −0.289 | −0.108 | 0.259 |
| | | (0.173) | (0.210) | (0.536**) | (0.664**) |
| Arch | | | | | |
| circumference | | | | | |
| | Maxilla | 0.078 | −0.067 | −0.158 | 0.034 |
| | | (0.000) | (−0.200) | (0.352*) | (0.595**) |
| | Mandible | 0.061 | −0.060 | −0.008 | 0.184 |
| | | (0.100) | (0.002) | (0.373*) | (0.637**) |

Significant difference from zero at the levels of 5%* and 1%**.
Correlation coefficients between the interdental spaces and the ages, and between dental arches and the ages are shown in parentheses.
Eleven male and seven female monozygotic twin pairs were examined.

These results agree with those of Baume[7] and Moorrees[12]. The corresponding correlation coefficients in intrapair difference were not significant (Table 4).

In 6-to-8-year group, the correlation coefficients in dental arch size were significantly different from zero, showing that the dental arch size increases largely (in parentheses in Table 4). These results agree well with the fact that there is a great increment in the dental arch size when deciduous teeth are lost and their permanent successor emerges, as described by Moorrees[12]. On the other hand, intrapair difference in dental arch size did not change, though the dental arch size increased largely.

*Examination of interdental spaces and dental arches at 4 years of age.*

Regarding the causal factors for interdental spaces, it is necessary to consider the relationship between the interdental space and the tooth size, and between the interdental space and dental arch size. The correlations

Table 5. Partial and simple (in parentheses) correlation coefficients between interdental spaces and dental arches and between interdental spaces and tooth sizes

| | Dental arch | | Tooth size |
|---|---|---|---|
| | Intercanine distance | Arch circumference | |
| Interdental space | | | |
| Precanine space | | | |
| Maxilla | 0.560* | 0.655** | −0.705** |
| | (0.570**) | (0.533*) | (−0.329) |
| Mandible | 0.682** | 0.662** | −0.833** |
| | (0.657**) | (0.624**) | (−0.304) |
| Postcanine space | | | |
| Maxilla | 0.442 | 0.547* | −0.853** |
| | (0.327) | (0.212) | (−0.699**) |
| Mandible | 0.418 | 0.408 | −0.603** |
| | (0.411) | (0.342) | (−0.601**) |

Significant difference from zero at the levels of 5%* and 1%**.

between the sizes of the interdental space and the tooth size, and between the sizes of interdental space and of dental arch were estimated (Table 5). Twenty-one individuals of elder co-twin group [A] of monozygotic and dizygotic twins at the age of 4 were used to estimate these correlation coefficients.

*(a) Coefficients of simple correlations (in parentheses in Table 5)*

Correlation coefficients between precanine space and intercanine distance and between precanine space and arch circumference were significantly different from zero in both maxilla and mandible ($p<0.05$), but those between precanine space and tooth size were not significant ($p<0.05$). Correlation coefficients between postcanine space and tooth size were significantly different from zero in both jaws ($p<0.05$), but those between postcanine space and dental arches (intercanine distance and arch circumference) were not significant ($p<0.05$).

*(b) Coefficients of partial correlations (Table 5)*

The coefficients of correlation between precanine space and others (dental arch and tooth size) were all significantly different from zero in both jaws ($p<0.05$–$0.01$). The coefficients of correlation between postcanine space and tooth size were significantly different from zero ($p<0.05$–$0.01$), and those between postcanine space and arch circumference in maxilla was significant ($p<0.05$).

To estimate the relative importance of the genetic and environmental factors for variation in the interdental spaces and dental arches, a comparison was made on mean variances (Tables 6 and 7).

(a) The ratios of the variance of measurement error and the mean intrapair variance of monozygotic twins: Variance ratios obtained were significant for all measurements ($p<0.05$) (Tables 6 and 7). These results indicated that the environmental factors in monozygotic twins were large enough to exceed the measurement errors. Since the mean intrapair variances of dizygotic twins were larger than those of monozygotic twins (Tables 6 and 7), it would be reasonable that the same results would be obtained in dizygotic twins if compared with the measurement errors.

(b) The ratios of the mean intrapair variances in monozygotic and

Table 6. Mean variance of interdental spaces

| | No. of twin pairs | Precanine space | | Postcanine space | |
|---|---|---|---|---|---|
| | | variance | F ratio | variance | F ratio |
| Maxilla | | | | | |
| Error | 10 | 70 | 10.51** | 10 | 25.60** |
| MZ intrapair | 11 | 736 | 1.81 | 256 | 1.32 |
| DZ intrapair | 10 | 1331 | 2.85 | 339 | 4.28* |
| DZ interpair | 10 | 3792 | | 1451 | |
| Mandible | | | | | |
| Error | 10 | 26 | 24.73* | 96 | 3.30* |
| MZ intrapair | 11 | 643 | 1.51 | 317 | 2.92* |
| DZ intrapair | 10 | 970 | 1.36 | 912 | 4.14* |
| DZ interpair | 10 | 1324 | | 3778 | |

* $p<0.05$, ** $p<0.01$.
MZ=monozygotic twins, DZ=dizygotic twins.

Table 7. Mean variance of dental arches

| | No. of twin pairs | Intercanine Distances | | Arch Circumference | |
|---|---|---|---|---|---|
| | | Variance | F ratio | Variance | F ratio |
| Maxilla | | | | | |
| Error | 10 | 428 | 7.47** | 743 | 7.22** |
| MZ intrapair | 11 | 3199 | 3.21* | 5365 | 4.18* |
| DZ intrapair | 10 | 10268 | 2.59 | 22428 | 3.29* |
| DZ interpair | 10 | 26644 | | 73770 | |
| Mandible | | | | | |
| Error | 10 | 466 | 2.03 | 1721 | 3.41* |
| MZ intrapair | 11 | 945 | 14.85* | 5868 | 4.66* |
| DZ intrapair | 10 | 14036 | 3.05* | 27329 | 2.49 |
| DZ interpair | 10 | 42861 | | 68154 | |

* $p<0.05$, ** $p<0.01$.
MZ=monozygotic twins, DZ=dizygotic twins.

dizygotic twins: Variance ratio in the interdental spaces was only significant in the postcanine space of the mandibular dentition ($p<0.05$) (Table 6). Variance ratios in the dental arches were all significant in both intercanine distances and arch circumferences. These results on the dental arches suggest that there were relatively large genetic factors for variation in dental arches (Table 7).

(c) The ratios of the mean intrapair and interpair variances in dizygotic twins: Variance ratios in interdental spaces were significant in the postcanine spaces of both jaws ($p<0.05$) (Table 6). Variance ratios in dental arches were significant in the mandibular intercanine distance and maxillary arch circumference ($p<0.05$) (Table 7).

## Discussion

In order to evaluate the causal factors for interdental space in the deciduous dentition at the age of 4, the extent to which the tooth size and dental arch size influence the size of interdental space was examined, and the degree of relative importance of genetic and environmental factors of variation for the interdental space, which is regarded as a metric trait, and dental arch was estimated.

Prior to the final analysis, effects of birth order, difference between left and right sides of dentition, sex difference, and age difference were examined on the twin data. No significant differences in measurements were found between the elder and younger twins and between left and right sides of the dentition. It would be possible to treat two groups of twins classified by birth order or by the side of dentition as equivalent. In general, interdental spaces in male twins seemed to be larger than those in female twins at the age of 6 years. The permanent teeth, first permanent molars or central incisors, erupted in 5 out of 7 female twin pairs and in 2 out of 11 male twin pairs at the age of 6 years. It seems that the stage of growth and development of jaw or dentition were more advanced in females than in males at this age. During 4 to 6 years of age, the size of interdental space and dental arch, and their intrapair difference did not change.

Therefore, these facts would suggest that the detection of causal factors for interdental space in the deciduous dentition at the age of 4 years is significant.

The extents to which the size of interdental spaces is affected by the tooth size and dental arch size were estimated from the correlation between interdental space and tooth size or dental arch size (Table 5). In maxillary precanine space (Table 5), simple correlations between the interdental space and tooth size are not significant in both jaws, while, the corresponding partial correlations in which effect of dental arch is not involved are significant. This result shows that the effect of dental arch sizes which are involved in simple correlations between precanine spaces and tooth sizes are large. Then, partial correlation would be suitable for detecting the causal factors for interdental space. From the results shown in Table 5, it was found that the precanine space is due to the tooth size and dental arch size, and that the postcanine space is due only to tooth size.

It would be considered another factor, that is, muscular force, which determines the interdental space. The extent to which arch form is determined by the balance of forces between the lips and cheeks on the outside and the tongue within, although considered of prime importance by some orthodontists[43)], is probably of minor significance in the determination of normal arch form[44,45)]. However, it seems that there is a few applicable methods which can evaluate the influences of muscular forces on the deciduous dentition, but examination on the muscular forces was not examined in this study.

The degree of relative importance of genetic and environmental factors for variation in the interdental space and dental arch was estimated from the analysis of variance. As shown in Tables 6 and 8, in the interdental spaces, the variance ratios between the mean intrapair variance of monozygotic twins and of dizygotic twins was only significant in the postcanine space of the mandibular dentitions. It may be possible that only the variation of the postcanine space of the mandibular dentition was larger in dizygotic twins than in monozygotic twins. In other words, variations in interdental spaces except the postcanine space of mandibular dentition were similar in both monozygotic and dizygotic twins. On the other hand, it is also possible that these results were obtained by chance because the number of materials was not large enough. The variance ratios and heritability estimates shown in Tables 6, 7, and 8 indicate at least that the genetic factors for variation in interdental space are smaller than those for dental arch.

Table 8. Heritability estimates

| | Maxilla | Mandible |
|---|---|---|
| Precanine space | 0.45 | 0.34 |
| Postcanine space | 0.24 | 0.65* |
| Intercanine distance | 0.69* | 0.93* |
| Arch circumference | 0.76* | 0.79* |

$$\text{Heritability (H)} = \frac{X(DZ) - V(MZ)}{V(DZ)}$$

* Variance ratios between mean intrapair variances of monozygote V(MZ) and those of dizygote V(DZ) were significant at the 5% level (see Tables 6 and 7).

Korkhaus[19], Goldberg[20], and Newton[21] suggested that the occurrence of interdental spaces in the deciduous dentition may be due to genetic factors. However, their investigations were carried out by the qualitative examination of deciduous dentition of twins and triplets, and no quantitative difference between the members of twins was taken into account. Accordingly, it is impossible to compare the findings of Korkhaus, Goldberg, and Newton with those in the present study.

Large genetic contributions to morphological variation in tooth and jaw have received considerable support from twin and family evidences[22-28]. In the present study, it was also found that the genetic factors for variation in dental arch size were large. As stated previously, the correlations between the interdental space and tooth size, and between the interdental space and dental arch size were statistically significant (Table 5). For instance, in correlation between interdental space and tooth size, the larger the tooth size is, the smaller was the interdental space. On the other hand, it was revealed that the genetic factors were small for variation in interdental space, which is regarded as a metric trait. Why are the genetic factors for variation in interdental space small? It is known that the canine area, where the anterior and posterior teeth meet, is an unstable region in the dentition[45]. Therefore, it is possible that the interdental spaces in the canine region are likely to be influenced by environmental factors. It is also suggested that the genetic factors for variation in tooth size and dental arch size are independent, and these are possibly included in the environmental factors for variation in interdental space.

Thus, in the possible explanation for the small genetic contribution to interdental space, it may be reasonable to regard the genetic factors for variation in the tooth and dental arch as being part of environmental factors for variation in interdental space. It may be considered that the causal factors for interdental space are due to the interaction of the development of tooth and dental arch.

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