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The association between the spacing of the incisors in the temporary and permanent dentitions of the same individuals

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SUMMARY The purpose of this investigation has been to study the association between the space conditions of the deciduous and permanent incisors of the same individuals.

The space conditions are determined as the difference between the length of the dental arch from canine to canine and the sum of the widths of the incisors. The association between the space conditions is expressed by the correlation coefficient, r.

The material consists of 50 series of models from the upper jaw, and 47 series of models from the lower jaw, each series of models covering the development from the deciduous to the adult dentition.

It was found that a statistically significant correlation between the space conditions could be shown in the upper, but not in the lower jaw. An examination of the determination coefficients, however, showed that in the individual case the development could not be accurately predicted, either in the upper or in the lower jaw.

The difference between the conditions in the maxilla and the mandible was further stressed by the finding, that the standard deviations of the space values are very small among the lower permanent incisors.

Introduction

The growth and development of the face and the dentition has, for a long time, been the object of increasing interest. The aim of this investigation has been to examine a detail in this facial maturation process, the association between the incisor spacing in the deciduous and permanent dentitions of the same individuals. From a clinical point of view it has furthermore been considered of interest to analyse the accuracy by which the incisor spacing in the adult can be predicted from the knowledge of the incisor spacing in the deciduous dentition.

Material

The investigation is carried out on a longitudinal material collected by Professor A Björk in Vasterås, Sweden. This material consists of 90 cases with models taken at different intervals from the deciduous dentition until adult age.

With the exception of one case with a missing second lower premolar, the present examination is limited to cases with all the permanent teeth except the third molars present. Cases with supernumerary teeth, cone-shaped lateral incisors, extensive caries, etc., were excluded, and furthermore the cases were excluded in which the eruption of the permanent incisors had started on the first models.

After these exclusions the analysed material consisted of 50 series of models from the upper jaw and 47 series of models from the lower jaw.

As the examination is only concerned with the conditions in the deciduous and permanent dentitions, only the first and last models of each series were used.

The average age among the first models was in the upper jaw 5^{4} years and in the lower jaw 5^{1} years. Among the last models the average age in the upper jaw was 17^{11} years and in the lower jaw 17^{7} years.

Measurements

As the purpose of the investigation is to throw some further light upon the association between the space conditions of the deciduous and permanent incisors, it is first of all necessary that an appropriate expression for this space can be obtained. In the past several different methods have been used. Lewis and Lehman (1933) divided their material by eye in groups of different degrees of spacing, distinguishing between no, slight, medium, and wide spacing. Seemingly they did not consider the crowding, but on the other hand they also divided the same material into groups of different degrees of alignment, distinguishing between good, fair, and poor alignment. The combination no spacing and poor alignment thus probably comprises the cases which by others are classified as crowding cases.

Korkhaus and Neumann (1931) and Baume (1948) also evaluated the space conditions by eye, but these authors only distinguished between cases with spacing and cases without spacing.

Seipel (1946) metrically determines spacing either as the space between adjacent teeth or as the difference between sectional space and the sum of the tooth widths. The sectional space is determined as the shortest distance between the limiting surfaces of a group of one or several

teeth. Crowding is also measured as the difference between sectional space and tooth widths, which gives a negative value. Seipel (1946) however treats the spacing and crowding values separately, and thus only indirectly arrives at the average space values of the dental arch.

Lundström (1948) determines the space metrically as the difference between the size of the dental arch and the sum of the tooth widths. The size of the dental arch is measured in sections of two teeth plus the width of the medial diastema when present. In his investigation, Lundström (1948) determines partly the space of each side of the dental arches (M_1-I_1) and partly the space of the incisor region (I_2-I_2).

Moorrees and Reed (1954) measured spacing with metal wires of known diameter, while crowding was determined as the tooth size minus the available space.

Among these authors thus only Seipel (1946) and Lundström (1948) have determined the space conditions as the difference between the size of the dental arch and the sum of the tooth widths.

In the present study the space conditions of the dental arch are determined according to the method of analysis employed at the Orthodontic Department of the Royal Dental College, Copenhagen (Fig. 1).

The space value in the front region is determined as the difference between the perimeter of the dental arch from canine to canine, and the sum of the widths of the incisors. The space condition is thus represented with a single value for the whole incisor region, being positive in case of spacing and negative in case of crowding.

In principle this is in accordance with the method used by Lundström (1948) though it differs as concerns the location of the measuring points.

The perimeter is defined as the section of the dental arch between the mesial contact points of the canines. It is measured from the mesial contact points of the canines to the mesial contact points of the central incisors, and the values from the right and left sides are added. In cases with medial diastema this distance is added. If the contact points of the central incisors overlap, the one which is in best alignment with the arch is used.

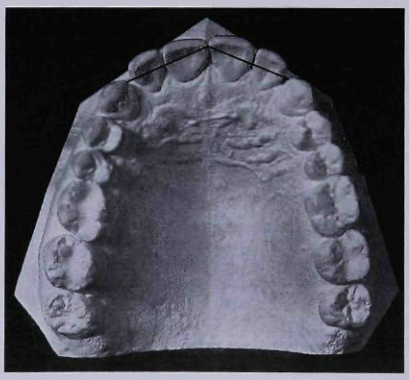

Figure 1 The space conditions of the incisors are determined as the difference between the perimeter of the dental arch from canine to canine and the sum of the widths of the incisors.

Determining the *width of the incisors,* the greatest mesiodistal width of each tooth has been used. In cases where it has not been possible to determine the width of one of the central or lateral incisors because of caries or too early loss of the deciduous teeth, the width of the corresponding tooth in the opposite side has been used.

All the measurements have been made with a sliding calliper, and the readings have been made with the accuracy of 1/10 mm. Measuring the tooth sizes, the sliding calliper was held parallel to the line of occlusion.

Statistical methods

The statistical data are given in Table 1.

In the statistical handling of the space values the following methods have been used.

For the characterisation of the distributions the arithmetical mean (M), the standard error of the mean (SE), and the standard deviation (SD) are used, Table 1, columns 1 to 4.

The association between the space conditions in the deciduous and permanent dentitions is expressed by the correlation coefficient (r), column 5. Owing to the limited size of the sample, the significance of the correlation coefficient is tested by Student's *t*-test, column 6. Comparisons of two correlation coefficients have been made after transformation to Fisher's *z*-values.

If the probability of the correlation coefficient differing from zero is greater than 99.9 per cent, the correlation is regarded as highly significant (***). If this probability lies between 99.9 and 99 per cent, the correlation is regarded as significant (**), and if it lies between 99 and 95 per cent, the correlation is regarded as probably significant (*).

When a significant correlation between the two variables is present, it is possible, by means of a regression analysis, to determine the average value of one of the variables, which corresponds to a given value of the other variable. In this case we want to know the average space value in the permanent dentition which corresponds to a given space value in the temporary dentition. For this purpose the regression coefficient ($b_{y/x}$) is given in column 7.

It should be noted, however, that the adult space value, which is determined by the regression analysis, is an average value only. For clinical purposes it is of considerably greater importance to be able to predict the development in the individual case. It is therefore necessary to know the accuracy with which the prediction in the individual case can be made. In this study the determination coefficient,

Table 1

	sex	N	Temporary dentition 1 M ± SE	2 SD	Permanent dentition 3 M ± SE	4 SD	5r	6t	$7b_{y/x}$	8d in per cent
Upper jaw	M	27	2.34 ± 0.40	2.06	0.24 ± 0.34	1.75	0.57**	3.47**	0.53	32
	F	23	1.97 ± 0.33	1.56	−0.21 ± 0.26	1.25	0.31	1.49	0.25	10
	M + F	50	2.17 ± 0.24	1.72	0.03 ± 0.22	1.54	0.49***	3.89***	0.44	24
Lower jaw	M	28	1.34 ± 0.34	1.80	−0.62 ± 0.18	0.93	0.26	1.37	0.13	7
	F	19	1.39 ± 0.35	1.50	−0.73 ± 0.18	0.80	0.38	1.60	0.21	14
	M + F	47	1.36 ± 0.24	1.67	−0.66 ± 0.13	0.87	0.30*	2.10*	0.16	9

which is equal to r^2, is used as a measure for this accuracy (Hyrenius, 1944).

The determination coefficient (d) expresses the amount of the total *y*-variance which is due to the regression, as shown by the following equation:

Total variance	variance due to	variance due to other
Total variance	regression	factors than regression

$$S_y^2 = S_y^2 \times r^2 + S_y^2 \times (1-r^2)$$

The determination coefficients are, in Table 1, column 8, expressed in per cent.

The determination coefficient illustrates a circumstance which is often disregarded in correlative computations, namely that the correlation coefficient must assume very large values before a prediction from one of the variables to the other can be made in the individual case. Even with correlation coefficients as large as e.g. 0.7 and 0.8 the *x*-variable is only responsible for about 50 and 65 per cent respectively of the total *y*-variance.

Findings

The association between the space conditions of the incisors in the deciduous and permanent dentitions of the same individuals has only been examined by few, despite the great interest this question at times has aroused.

Korkhaus and Neumann (1931), in a longitudinal study of 44 cases, investigated the transverse growth of the dental arch during the period of replacement of the incisors. At the same time the association between the space conditions in the deciduous and early mixed dentitions was also evaluated.

Lewis and Lehman (1933) computed the correlation between the alignment of the deciduous and permanent incisors, and the association between the spacing of the deciduous incisors and the alignment of the permanent incisors was also examined. The investigation was made on models from 75 cases followed for 8 years.

Baume (1943, 1947, 1948, 1949) followed 60 cases for 8 years from the deciduous to the mixed dentition. He examined the transverse growth of the dental arch, and in this connection the association between the space conditions of the temporary and permanent incisors is discussed.

The association between the space conditions was evaluated subjectively by Korkhaus and Neumann (1931) as well as by Baume (1943, 1947, 1948, 1949). Only by Lewis and Lehman (1933) was the association between the alignment of the incisors evaluated by means of a correlation coefficient. In all the investigations however, the evaluation of the space conditions was only made subjectively.

In order to eliminate the subjective factor, the space conditions in this investigation are evaluated metrically, and also the association between the space conditions of the deciduous and permanent incisors is expressed objectively by the correlation coefficient.

The correlation coefficient has been computed for each sex separately, and in view of the limited size of the sample, the correlation coefficient for both sexes together has also been computed.

A consideration of the conditions in the upper jaw (Table 1, columns 5 and 6) shows that the correlation is 0.57** for boys. This means that there is here a distinct and significant association between the space conditions in the deciduous and permanent dentitions. Cases with spacing in the deciduous dentition thus generally have a tendency for spacing in the permanent dentition too. For girls the correlation in the upper jaw is only 0.31 and not significant. The values for the two sexes, however, do not differ significantly, and if both sexes are considered together the correlation is 0.49***, and highly significant.

In the lower jaw no significant correlation can be found, neither for each sex separately nor for both sexes together.

The association between the space conditions is shown graphically for boys in Figures 2 and 3. In the upper jaw it clearly appears that an association exists, but despite this the dispersions are so great that a prediction of the conditions in the permanent dentition from the knowledge of the conditions in the deciduous dentition will prove to be very questionable in the individual case. As the correlation coefficient, however, is of a magnitude that may make a prediction of the general development actual, it is possible, by means of the regression line, to find the average space value in the permanent dentition, which corresponds to a given value in the deciduous dentition.

In the lower jaw (Fig. 3) the lack of association is evident, the main axis of the ellipse of distribution being almost

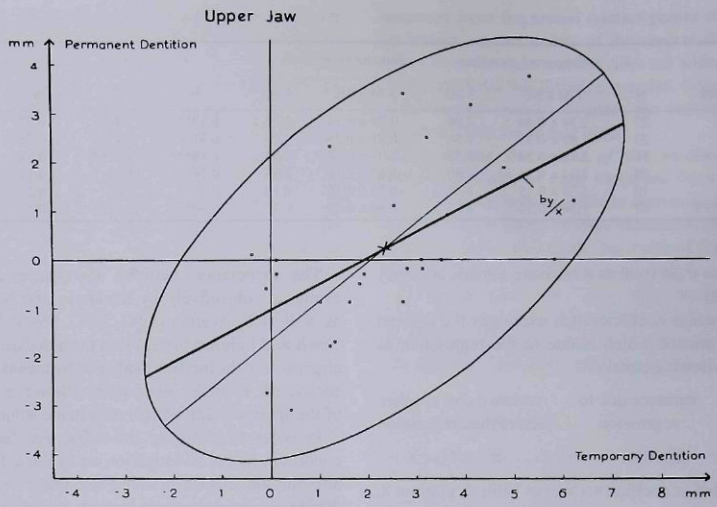

Figure 2 The association between the space conditions of the incisors in the deciduous and permanent dentition illustrated by the 95 per cent ellipse of distribution and the line of regression $b_{y/x}$. 27 cases from the upper jaw of boys.

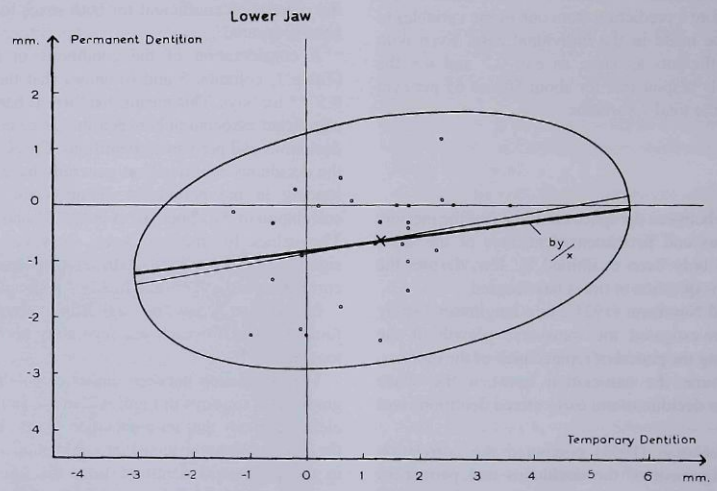

Figure 3 The association between the space conditions of the incisors in the deciduous and permanent dentitions illustrated by the 95 per cent ellipse of distribution and the line of regression $b_{y/x}$. 29 cases from the lower jaw of boys.

horizontal, and here it is not possible to predict the development at all.

In order to examine the accuracy by which the space conditions of the permanent incisors can be predicted in the individual case, the determination coefficient is used (Table 1, column 8). It will be seen that even in the upper jaw of boys, where the association is most evident, the determination coefficient is only 0.32. This means that the variation in the deciduous dentition only is responsible for 32 per cent of the variation in the permanent dentition, and the accuracy

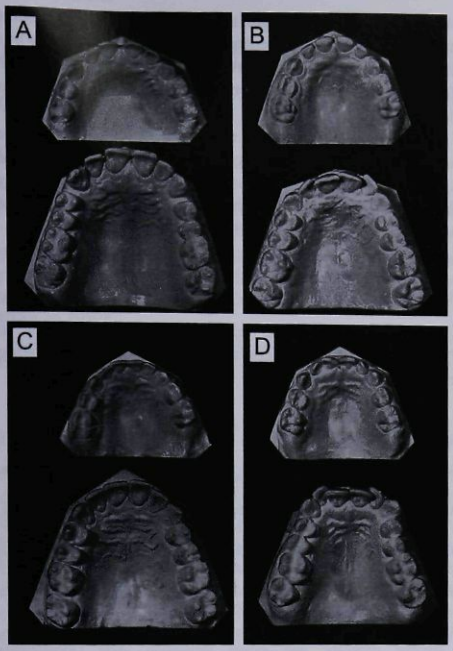

Figure 4 The variation in the individual development of the incisor spacing in the upper jaw of boys. A and B show incisor spacing in the deciduous dentition followed by spacing or by crowding of the permanent incisors. C and D show lack of incisor spacing in the deciduous dentition followed by normal alignment or by crowding of the permanent incisors.

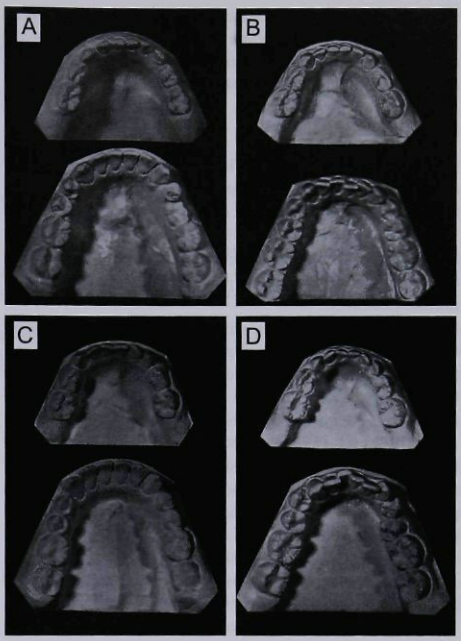

Figure 5 The variation in the individual development of the incisor spacing in the lower jaw of boys. A and B show spacing of the deciduous incisors followed by normal alignment or by crowding of the permanent incisors. C and D show crowding of the deciduous incisors followed by normal alignment or by crowding of the permanent incisors.

whereby a prediction in the individual case can be made is therefore correspondingly low. In the upper jaw of girls and in the lower jaw of both boys and girls the determination coefficient is considerably smaller, and here a prediction of the space conditions of the permanent incisors cannot be made with any degree of accuracy in the individual case.

As a demonstration of the variation in the individual development, four cases from each jaw are shown in Figures 4 and 5.

From Figures 4A and B it appears, that in the upper jaw spacing in the deciduous dentition may develop into spacing or crowding in the permanent dentition. Figures 4C and D show that lack of spacing in the deciduous dentition may develop either into normal position or crowding in the permanent dentition. These cases, which all are boys, thus further stress that even where the association between the space conditions is most marked, the individual variation is so great, that it is not possible in the single case to predict how the development will be.

In the lower jaw an even greater variation can be found. Figures 5A and B show cases with spacing in the temporary dentition followed by normal alignment or crowding in the permanent dentition, while Figures 5C and D show cases with crowding in the temporary dentition also followed by normal alignment or crowding in the permanent dentition.

Turning again to Table 1 and examining the standard deviations of the two age groups (columns 2 and 4), we find that in the upper jaw a comparison of the standard deviations shows no appreciable differences, while in the lower jaw a very remarkable difference is found. Here the standard deviations in the permanent dentitions are only about half as big as in the deciduous dentitions. This is the more striking when it is taken into consideration, that during the growth the standard deviation usually increases until puberty, whereafter it falls slightly, so that the standard deviation in the adult usually is larger than in the child (Tuddenham and Snyder, 1954).

An examination of the means of the space values (Table 1, columns 1 and 3) shows that generally a certain degree of spacing is found in the deciduous dentition, most pronounced in the upper jaw (M = 2.2 mm.), and somewhat less in the lower jaw (M = 1.4 mm.). In the permanent dentition

spacing in the upper jaw is found as frequently as crowding, while spacing in the lower jaw appears to a somewhat lesser extent than crowding. These findings are in accordance with those presented by Seipel (1946).

Discussion

In the literature some differences in opinion prevail concerning the association between the space conditions in the deciduous and permanent dentitions.

Korkhaus and Neumann (1931) conclude that even when there is no spacing in the deciduous dentition it happens comparatively often that the permanent incisors come into normal positions.

Lewis and Lehman (1933) found no significant correlation ($r = 0.0008$) between the alignment of the deciduous and permanent incisors. Neither did they find any association between the spacing of the deciduous incisors and the alignment of the permanent incisors.

Finally Lewis (1936) maintains that the essential factors in attaining correct position of the permanent incisors are the growth changes before and under the eruption of the permanent incisors, and not the occurrence of spacing of the deciduous incisors.

Contrary to this Baume (1943) claims that lack of spacing in the deciduous dentition almost without exception is followed by crowding and jaw compression in the permanent dentition. Baume (1948), however, moderates this opinion, stating that deciduous dentitions with spacing display a remarkably favourable tendency of development, while deciduous dentitions with closed dental arches to a great extent tend to wrong development in the direction of jaw compression.

The results of this investigation can be divided into two groups. In the upper jaw an association between the space conditions of the deciduous and permanent incisors can be proved statistically. The correlation, however, is so moderate, that in the individual case it will only be possible with very small accuracy to predict how the development will be.

In the lower jaw no statistically significant correlation can be shown. Consequently a prediction of the space conditions of the lower permanent incisors cannot be made at all.

Considering the results it must be remembered, however, that because an association cannot be found from the present material, it does not necessarily mean, that such an association does not exist.

The cause can equally be that the material is too small for the demonstration of a possible association.

The difference between the results in the upper and lower jaws is further stressed by the fact that in the upper jaw the standard deviations of the space values are of the same magnitude in the permanent and deciduous dentitions, while in the lower jaw the standard deviations of the permanent dentitions are much smaller than those of the deciduous dentition.

As a possible explanation of these differences it could be assumed that the modelling of the dental arches by the tongue, the lips, and the opposing teeth would be particularly active in the lower incisor. This would thus be in accordance with observations made by Björk and Palling (1954).

Acknowledgement

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