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THE ASSOCIATION BETWEEN SPACING OF THE INCISORS IN THE TEMPORARY AND PERMANENT DENTITIONS OF THE SAME INDIVIDUALS

by

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During the last decades the growth and development of the face and the dentition have been the object of increasing interest. The aim of the present investigation is to examine a detail in the facial maturation process, viz. 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 was carried out on a longitudinal material collected by Professor A. Björk in Västerås, Sweden. This material consists of 90 cases with models taken at different ages from the deciduous dentition until adult age.

With the exception of one case in which a second lower premolar is missing, the present study 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. Furthermore cases were excluded in which the eruption of the permanent incisors had started at the time the first models were made.

This paper was presented at the Congress of the European Orthodontic Society, Copenhagen, July 4—8, 1958.

The analysed material consisted of 50 series of models from the upper jaw and 47 series of models from the lower jaw.

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

The average age of the children represented by the first series of models was for the upper jaw 5 years and 4 months and for the lower jaw 5 years and one month. Among the last model series the average age for the upper jaw was 17 years and 11 months and for the lower jaw 17 years and 7 months.

MEASUREMENTS

As the purpose of the present investigation is to study the association between the space conditions of the deciduous and permanent incisors, it is necessary that an appropriate expression for this space be obtained. In the past several methods have been used.

Lewis & Lehman (1932) 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 crowding. On the other hand, however, they divided the same material into groups with different types 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.

Korkhaus & 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 determined 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 was determined as the shortest distance between the limiting surfaces of a group of one or several teeth. Crowding was also measured as the difference between sectional space and tooth widths (negative values). *Seipel,* however, treated the spacing and crowding values separately, and thus only indirectly arrived at the average space values of the dental arch.

Lundström (1948) determined the space metrically as the dif-

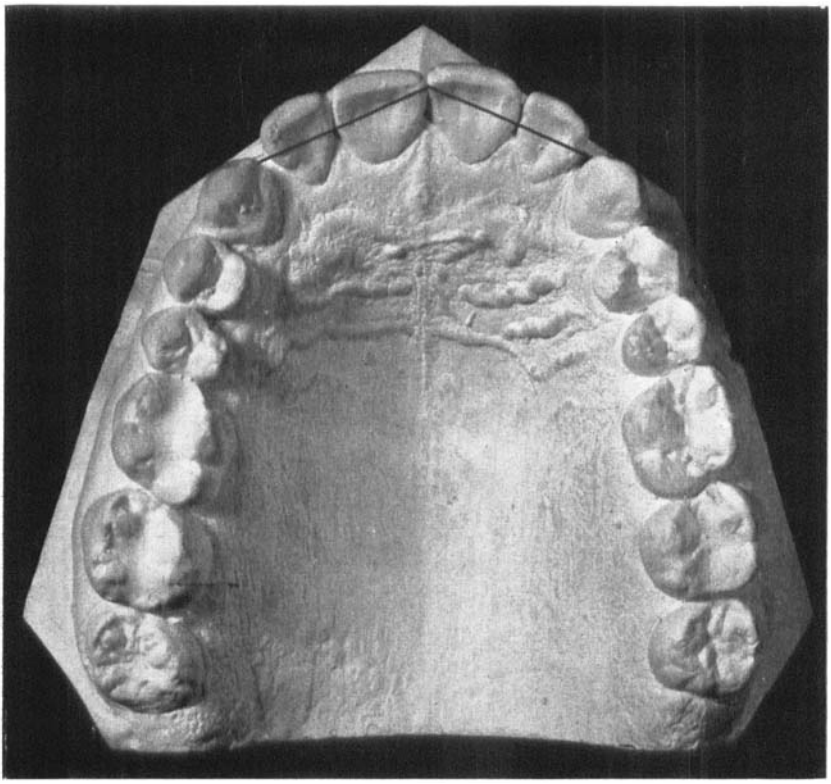

Fig. 1. The space conditions of the incisors are determined as the difference between the perimeter of the dental arch from canine to canine and the sum of the widths of the incisors.

ference between the circumference of the dental arch and the sum of the tooth widths. The circumference of the dental arch was measured in sections of two teeth plus the width of the medial diastema when present. *Lundström* determined the space of each side of the dental arches (M_1—I_1) as well as the space of the incisor region (I_2—I_2).

Moorrees & Reed (1954) measured spacing by means of 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 circumference of the dental arch and the sum of the tooth widths.

In the present study, the space conditions of the dental arches 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 by 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 circumference 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.

In 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 premature loss of the deciduous teeth, the width of the corresponding tooth in the opposite side has been used.

All the measurements were taken with a sliding calliper, and the readings were made with an accuracy of 1/10 mm. In measuring the tooth sizes the sliding calliper was held parallel to the line of occlusion.

STATISTICAL METHODS

The statistical data are given in Table I.

In the statistical handling of the space values the following methods were used:

For the characterisation of the distributions the arithmetical

Table 1.

			Temporary dentition		Permanent dentition					
	Sex	N	1 M ± S. E.	2 S. D.	3 M ± S. E.	4 S. D.	5 r	6 t	7 $b_{y/x}$	8 d 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

mean (M), the standard error of the mean (S.E.), and the standard deviation (S.D) were used, Table I, columns 1—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 were 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 the present 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, which is equal to r^2, is used as a measure for this accuracy, (*Hyrenius*, 1954).

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 regression		variance due to other factors than regression
S^2y	=	$S^2y \times r^2$	+	$S^2y \times (1 - r^2)$

In Table I, column 8, the determination coefficients are expressed in per cent.

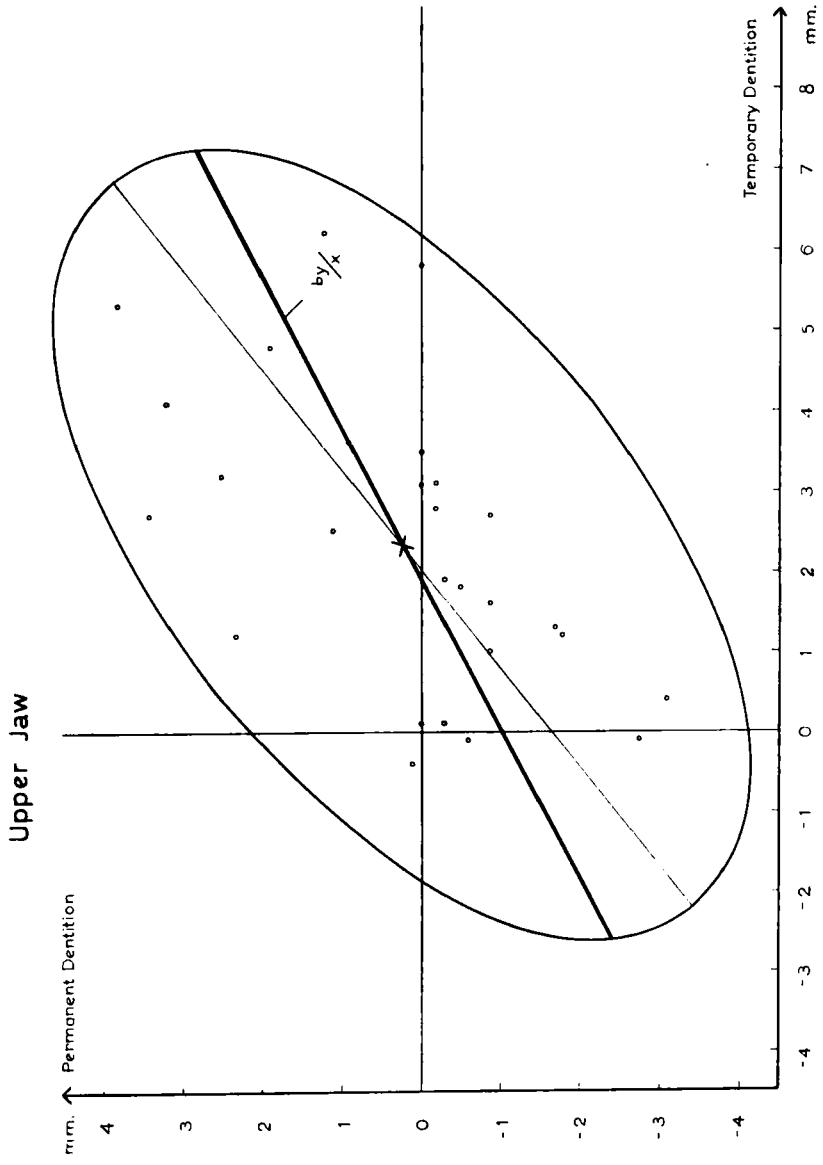

Fig. 2. The association between the space conditions of the incisors in the deciduous and permanent dentitions illustrated by the 95 per cent ellipse of distribution and the line of regression b y/x.
27 cases from the upper jaw of boys.

The determination coefficient illustrates a circumstance which is often disregarded in correlative computations, viz. 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

Despite the great interest this question has aroused, 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 workers.

Korkhaus & Neumann (1931), in a longitudinal study of 44 cases, investigated the transversal 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 & Lehman (1932) computed the correlation between the alignment of the deciduous and permanent incisors. The association between spacing of the deciduous incisors and alignment of the permanent incisors was also studied. 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 transversal growth of the dental arch, and in this connexion the association between the space conditions of the temporary and permanent incisors was discussed.

The association between the space conditions was evaluated subjectively by *Korkhaus & Neumann* as well as by *Baume*. Only by *Lewis & Lehman* was the association between the alignment of the incisors evaluated by means of a correlation coefficient. In all investigations, however, the evaluation of the space conditions was made subjectively.

In order to eliminate subjective factors, the space conditions in the present investigation were evaluated metrically. Also, the association between the space conditions of the deciduous and

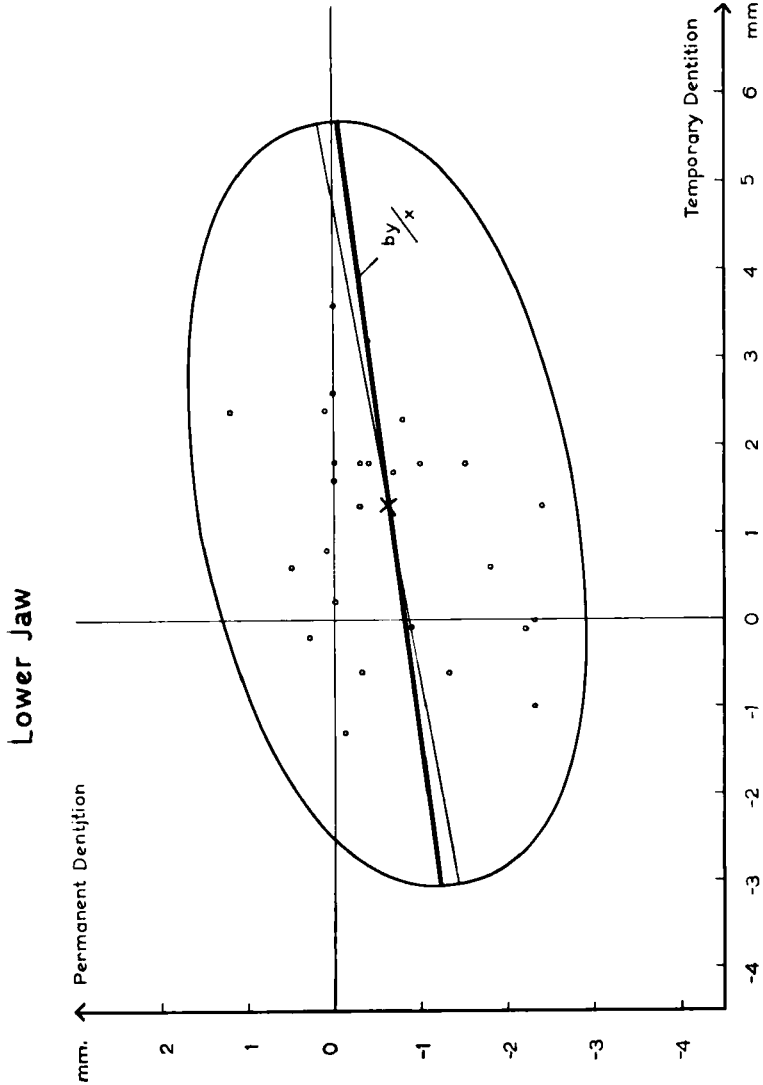

Fig. 3. The association between the space conditions of the incisors in the deciduous and permanent dentitions illustrated by the 95 per cent ellipse of distribution and the line of regression $b_{y/x}$. 29 cases from the lower jaw of boys.

permanent incisors was expressed objectively by the correlation coefficient.

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

A consideration of the conditions in the upper jaw (Table I, columns 5 and 6) shows that the correlation is 0.57** for boys. This means that in boys there is 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 Figs. 2 and 3. It clearly appears that an association exists in the upper jaw, 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. The correlation coefficient, however, is of a magnitude that makes prediction of the general development possible, and by means of the regression line, (Fig. 2), it is therefore possible 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 elipse of distribution being almost horizontal, and here it is not possible to predict the development at all.

In order to determine the accuracy with which the space conditions of the permanent incisors can be predicted in the individual case, the determination coefficient is used (Table I, column 8). 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

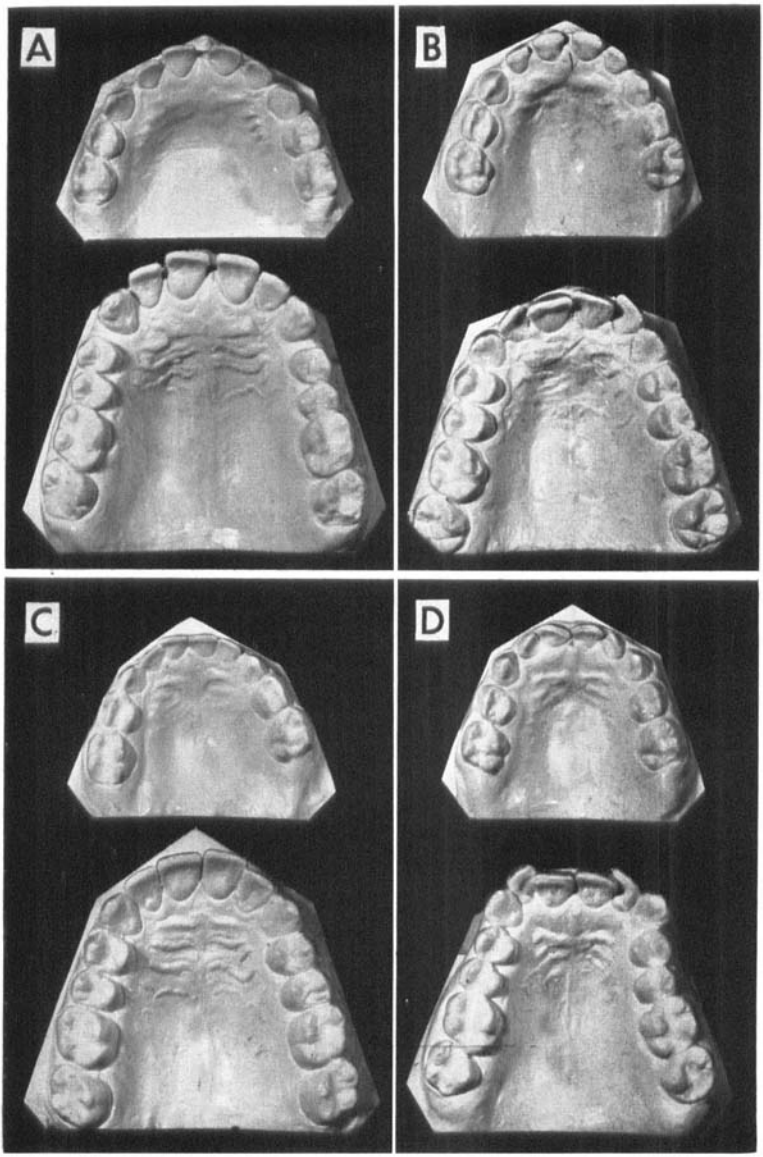

Fig. 4. The variation in individual development of the incisor spacing in the upper jaw of boys. A and B show incisor spacing in the deciduous dentition followed by spacing or by crowding of the permanent incisors. C and D show lack of incisor spacing in the deciduous dentition followed by normal alignment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

the accuracy whereby a prediction in the individual case can be made is therefore correspondingly small. 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 individual development, four cases from each jaw are shown in Figs 4 and 5.

From Figs. 4 A and B appears, that in the upper jaw spacing in the deciduous dentition may develop into spacing or crowding in the permanent dentition. Figs. 4 C 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 are boys further stress that even in boys where the association between the space conditions is most marked, the individual variation is so great, that it is impossible in the single case to predict how the development will be.

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

In Table I (columns 2 and 4), we find that in the upper jaw a comparison of the standard deviations of the two age groups shows no appreciable differences, while a very remarkable difference is found in the lower jaw. In the latter case the standard deviations for the permanent dentition are only about half those for the deciduous dentition. This is the more striking when it is taken into consideration, that during growth the standard deviation usually increases until puberty, whereafter it falls slightly, so that in the adult the standard deviation usually is larger than in the child (*Tuddenham & Snyder*, 1954).

An examination of the means of the space values (Table I, 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

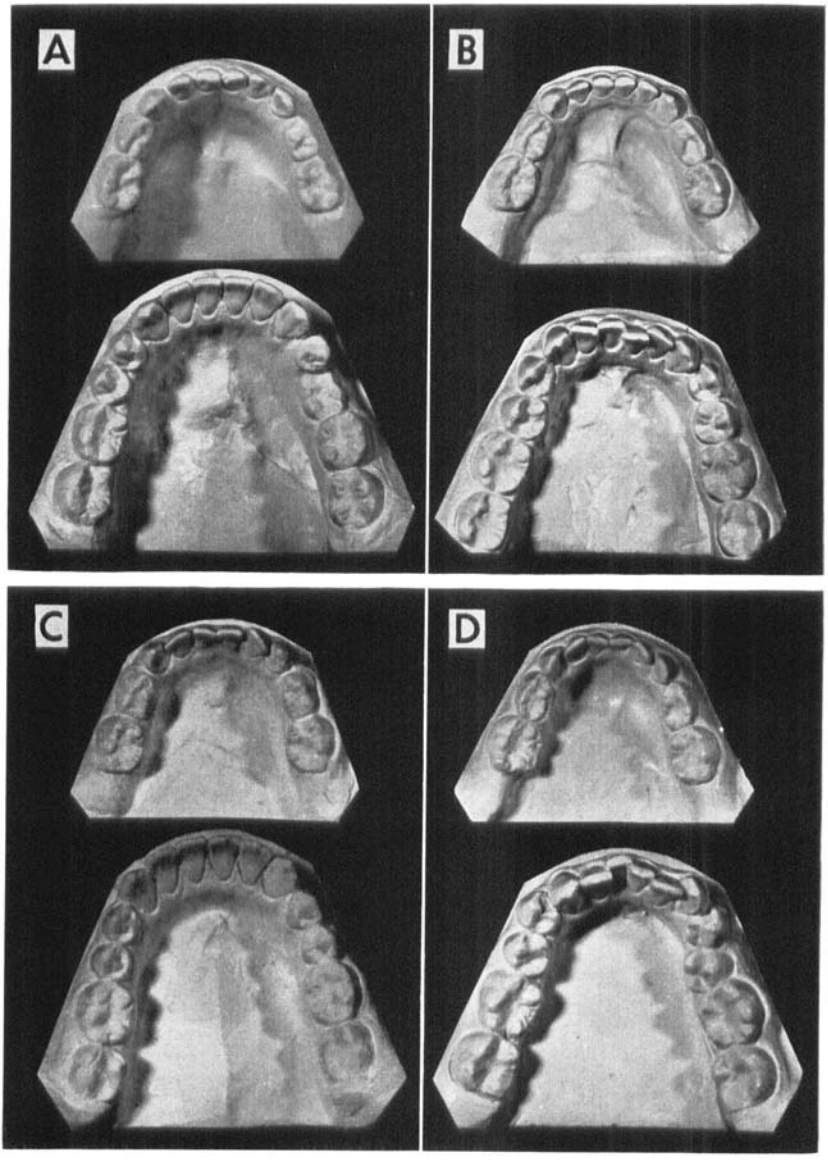

Fig. 5. The variation in individual development of the incisor spacing in the lower jaw of boys. A and B show spacing of the deciduous incisors followed by normal alignment or by crowding of the permanent incisors. C and D show crowding of the deciduous incisors followed by normal alignment or by crowding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

the lower jaw appears to a somewhat less extent than crowding. These findings are in accordance with those reported by *Seipel* (1946).

DISCUSSION

Some difference of opinion prevails in the literature concerning the association between the space conditions in the deciduous and permanent dentitions.

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

Lewis & Lehman (1932) found no significant correlation ($r = 0.0008$) between the alignment of the deciduous and permanent incisors. Neither did they find any association between spacing of the deciduous incisors and alignment of the permanent incisors.

Lewis (1936) maintains that the essential factors in attaining correct position of the permanent incisors are the growth changes before and during 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. Later (1948), however, *Baume* 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 are followed by permanent dentitions with jaw compression.

The results of the present investigation are different for the upper and lower jaws: For 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 not be possible to predict the development.

For 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.

It must be remembered, however, that because an association cannot be found in the present material, this does not necessarily mean that such an association does not exist. It might be that the material is too small for the demonstration of an 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 for the permanent dentition are much smaller than those for 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 pronounced in the lower incisor region. This would be in accordance with observations made by *Björk & Palling* (1954).

SUMMARY

The purpose of this investigation is 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 circumference 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 deciduous to adult dentition.

Statistically significant correlation between the space conditions could be shown for the upper, but not for the lower jaw. The determination coefficients, however, showed that in the individual case the development could not be accurately predicted, neither in the upper nor 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 for the lower permanent incisors.

The author wishes to express his indebtedness to Professor Björk for encouraging advice and stimulating interest in this work.

RÉSUMÉ

LE RAPPORT ENTRE LES CONDITIONS D'ESPACEMENT DES INCISIVES TEMPORAIRES ET PERMANENTES CHEZ LES MÊMES INDIVIDUS

Les conditions d'espacement sont déterminées comme la différence entre la circonférence de l'arcade dentaire de canine à canine et la somme des largeurs des incisives. Le rapport entre les conditions d'espacement est exprimé par le coefficient de corrélation, r.

L'ensemble étudié se compose de 50 séries de modèles de la mâchoire supérieure et 47 séries de modèles de la mâchoire inférieure. Chaque série représente le développement depuis la denture temporaire jusqu'à la denture adulte.

Il a été possible de démontrer une corrélation d'une valeur statistiquement significative entre les conditions d'espacement à la mâchoire supérieure, mais non pas à la mâchoire inférieure. Un examen des coefficients de détermination, cependant, démontra l'impossibilité de prédire avec exactitude le développement dans les cas particuliers, soit à la mâchoire supérieure, soit à la mâchoire inférieure.

La différence entre les conditions à la mâchoire supérieure et à la mâchoire inférieure a encore été soulignée par le fait que les déviations standards des valeurs d'espacement sont très petites pour les incisives permanentes de la mâchoire inférieure.

ZUSAMMENFASSUNG

DER ZUSAMMENHANG ZWISCHEN DEN PLATZVERHÄLTNISSEN DER MILCHZÄHNE UND DER PERMANENTEN ZÄHNE IN DENSELBEN INDIVIDUEN

Die Platzverhältnisse werden bestimmt als der Unterschied zwischen der Umkreis des Zahnbogens von Eckzahn bis Eckzahn und der Summe der Breiten der Schneidezähne. Der Zusammenhang zwischen den Platzverhältnissen wird durch den Korrelationskoeffizient, r, ausgedrückt.

Das Material besteht aus 50 Serien von Modellen des Oberkiefers und 47 Serien von Modellen des Unterkiefers. Jede Serie deckt die Entwicklung vom Milchgebiss bis zum erwachsenen Gebiss.

Eine statistisch signifikante Korrelation zwischen den Platzverhältnissen konnte im Oberkiefer, aber nicht im Unterkiefer,

gezeigt werden. Eine Untersuchung des Determinationskoeffizienten zeigte aber, dass die Entwicklung im individuellen Fall nicht vorhergesagt werden konnte, weder im Oberkiefer noch im Unterkiefer.

Der Unterschied zwischen den Verhältnissen im Oberkiefer und im Unterkiefer wurde ausserdem dadurch betont, dass die Standarddeviationen der Platzwerte der permanenten, unteren Schneidezähne sehr klein sind.

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