From The Department of Orthodontics
(Head: Professor ANDERS LUNDSTRÖM),
The Royal School of Dentistry, Stockholm

# INTERMAXILLARY TOOTH WIDTH RATIO AND TOOTH ALIGNMENT AND OCCLUSION

*by*

ANDERS LUNDSTRÖM

This article consists in the main of an extract from a paper published in 1943 in Swedish, supplemented by a survey of the subsequent literature on the subject.

## SURVEY OF THE LITERATURE

It would appear that the first to devote attention to the problem of the significance of the intermaxillary tooth width ratio in occlusion was *Young* (1923). In two cases having normal occlusion and different degrees of overbite he measured the widths of the $I_1$—$P_2$ in both jaws. In one case — distinguished by edge-to-edge occlusion — the difference between the sums of the tooth widths in the maxilla and the mandible was 0.43 inches (= 10.9 mm) while in the other case, with overbite, the figure was 0.67 inches (= 17.0 mm).

*A. M. Schwarz*, 1929 (2 cases) and *Mayer*[1] (75 left or right sides) have found indications that where the upper deciduous teeth are small compared with the lower there is a tendency towards post-normal position of the permanent first molars.

The *Lux* brothers (1930), *Ritter* (1933), *Seipel* (1946) and *Selmer-Olsen* (1949) have investigated the upper and lower tooth widths and found a fairly marked correlation. For the $M_1$—$M_1$ sums *Ritter* obtained a coefficient of $r = 0.67 \pm 0.05$ for 100 cases designated as normal, and $r = 0.82 \pm 0.03$ for 100 cases of malocclusion. *Seipel* found for 365 unselected cases a strong

[1] Reported by Korkhaus, 1930.

correlation between upper and lower tooth width sums of the $I_1$—$P_2$ ($r = +0.77 \pm 0.021$). He has also given mean ratios between the upper and lower teeth for various tooth groups and for the $M_2$—$M_2$ sum. For the permanent teeth he obtained the values:

$$I_{1+2} = 1.35,\ C = 1.14,\ P_{1+2} = 0.97,\ M_{1+2} = 0.95\text{: total } 1.06.$$

*Tonn* (1937) investigated the intermaxillary tooth width ratio in 50 cases with anatomically correct occlusion and in 20 cases that seemed to be characterized by disharmony in tooth width. A statistical analysis of the normal material gives the following mean values and dispersion:

| | Mean | Standard deviation |
|---|---|---|
| $I_{1+2}$ (lower to upper) | 0.74 | 0.024 |
| C ( " " " ) | 0.87 | 0.038 |
| $P_{1+2}$ (upper to lower) | 0.96 | 0.021 |
| $M_1$ ( " " " ) | 0.92 | 0.030 |
| Total (lower to upper) | 0.93 | 0.018 |

Of the 20 cases of malocclusion 8 had intermaxillary tooth width ratios that fell outside the range

$$\text{mean} \pm 3 \times \text{standard deviation}.$$

Of these, 6 presented abnormal incisor ratios and 2 abnormal premolar ratios. In 5 of the former cases the maxillary teeth, and in the sixth the mandibular teeth, were abnormally large, while the two latter had abnormally large maxillary teeth in relation to the mandibular.

*G. Körbitz* (1940) examined some 100 dentitions with anatomically correct occlusion. He states that the difference (upper incisors + canines) — (lower incisor + canines + ½ first premolars) should be between 0 and 4 mm, corresponding to an overbite of 0—3.5 mm. He found a difference of —3.3 mm in one case and, at the opposite extreme, + 8 mm in another.

*Neff* (1949) calculated arithmetically the degree of overbite (expressed as a percentage of the lower medial incisors covered by the uppers — seen from the front), that corresponded to different ratios between the upper and lower anteriors ($I_1 + I_2 + C$). He obtained the following values:

| | | | | | |
|---|---|---|---|---|---|
| Tooth width ratio: | 1.10 | 1.20 | 1.30 | 1.40 | 1.55 |
| Overbite | 0 | 20 % | 35 % | 55 % | 100 % |

*Steadman* (1949) defines the relation of the upper to the lower teeth as a difference between (1) the anterior tooth-widths in the lower jaw ($I_1 + I_2 + C$) and (2) the tooth-widths in a corresponding segment in the upper jaw ($I_1 + I_2 + \frac{1}{2} C$). To compensate for the labio-lingual thickness he adds to (1) one-half the labio-lingual thickness of the lower lateral incisor at the incisal third and substracts from (2) one-half the labio-lingual thickness of the upper central at the incisal third. Steadman states that if the difference between (1) and (2) is — 2 mm and the cuspids are in good class I relationship, an end-to-end bite will result while + 2 mm will produce excessive overjet.

## THE PRESENT INVESTIGATION

The best material for an investigation of tooth widths in living subjects would be provided by continuous observation of the development of the dentition and occlusion of a sufficiently large number of subjects. The widths could then be measured as soon as they had erupted far enough. The teeth that are not measureable would then be limited to those that are retained or were, before they were sufficiently erupted, so badly damaged that the required measurement could not be performed (enamel hypoplasias, caries, traumata). The period of observation for such a procedure would inevitably be very long. If all the permanent teeth from the $I_1$ to $M_1$ were to be measured, each subject would have to be observed from the age of 6 or 7 to 13 or 14 years.

It is generally impossible to measure the width of the $M_1$ before the eruption of the $M_2$, as the gingiva covers too much of the distal surface. For the same reason the $M_3$ must erupt before the $M_2$ is accessible. Moreover, in such study group a fairly large number of the $M_1$ and $M_2$ would not be measurable on account of destruction of the mesial surfaces by caries before the teeth had erupted far enough.

The most suitable time for an examination at a definite age is obviously when there is the greatest number of measurable teeth present. At lower and higher ages the number is smaller on account of incomplete eruption and carious lesions. At the age of 13–14 years the C, $P_2$ and $M_2$ have generally just erupted and the $I_1$, $I_2$, C, $P_1$, $P_2$ and $M_1$ are therefore accessible for measurement. This age is convenient also because at the end of the transition from the deciduous to permanent teeth the most important stage of the development of the occlusion is past.

The subjects chosen were pupils from the seventh year of an elementary school. Direct intra-oral measurements of the widths of the $I_1$, $I_2$ and C were made for all the pupils in the study group. The teeth posterior of the cuspids were not considered suitable for direct measurement as the lips and the opposite jaw obstructed the manipulation of the measuring instrument. Measurements were therefore made on plaster casts.

Impressions were taken and jaw casts prepared for the pupils of the prevailing age in the class. Hydrocolloid impression compound was used. The casts were of dental stone.

*Direct* measurements of the tooth width ($I_1$, $I_2$, C) were made on 319 (195 boys and 124 girls). *Cast* measurements ($I_1$, $I_2$, C, $P_1$, $P_2$, $M_1$) were made on 227 (140 boys and 87 girls) of the 237 pupils of the prevailing age. (For the remaining 10 cases the impression could not be taken — 2 on account of vomiting, 2 with orthodontic appliances, 4 with burns, cough, toothache and mouth sores, and 2 for which no reason was recorded).

Duplicate measurements were made and two casts prepared in 27 cases (11 boys and 16 girls).

The tooth alignment and occlusion were studied on the casts. From the viewpoint of age the material is very uniform:

| | *Boys* | | *Girls* | | *Total* | |
|---|---|---|---|---|---|---|
| | No. | Average age (yrs) | No. | Average age (yrs) | No. | Average age (yrs) |
| Casts taken | 140 | 13.6 | 87 | 13.6 | 227 | 13.6 |
| All cases | 195 | 13.9 | 124 | 13.8 | 319 | 13.8 |

## MEASUREMENT TECHNIQUE

The width of a tooth is understood in the following to mean the mesiodistal distance between its points of contact in anatomically correct occlusion, projected on the occlusal plane. It should be noted here that the occlusal plane is not a plane in the geometric sense but is characterized by an anterio-posterior curvature — Spee's compensation curve.

For the $M_1$, in addition to the actual tooth width, measurement was made of an anterior segment — extending from the mesial contact points to the mesio-buccal cusp tip in the maxilla, and to the fissure between the mesio- and distobuccal cusps in the mandible. These distances were measured in the appropriate mesiodistal direction for the teeth.

The measuring instrument was a slide guage with vernier scale. To overcome the difficulty arising from the fact that the

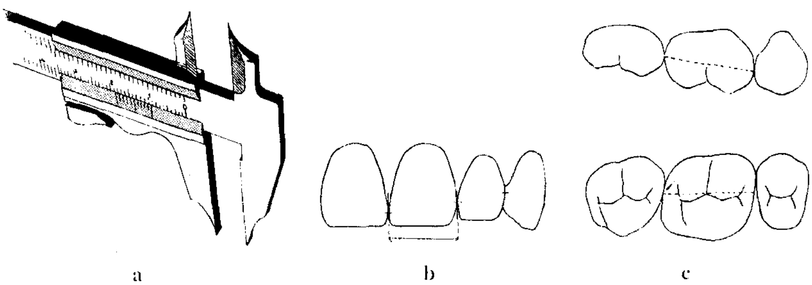


Fig. 1. Measuring of tooth-breadths. a. slideguage used. b. measuring of incisors with contact-points at different level has been made parallel to occlusion plane. c. measuring of 1st molars in the upper jaw has been made along dotted lines.

contact points of some teeth are at different heights in relation to the occlusal plane, one pair of the caliper arms were ground to sharp edges 2.7 mm in length. Differences in level were especially evident in the case of the $I_1$, $I_2$ and $M_1$ in the maxilla and the $I_2$ in the mandible, their distal contact points as a rule being somewhat more apically situated than the mesial (Fig. 1). In such cases the instrument was placed at right angles to the labial surface, as illustrated in Fig. 1.

As in some cases these edges may possibly have obstructed the measurement (especially where the teeth were crowded and slightly rotated) the opposite arms of the calipers were ground to sharp points so that either the edges or the tips could be used, whichever were the most convenient.

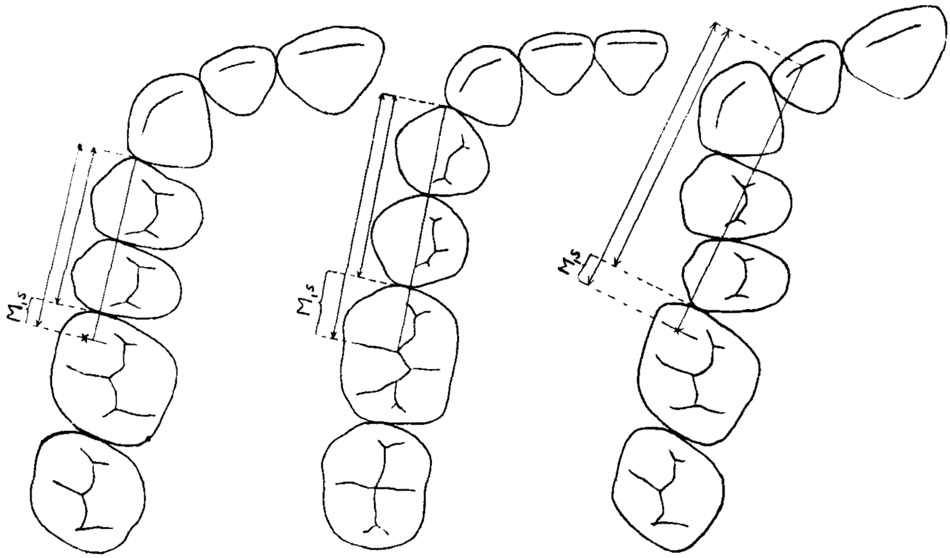


Fig. 2. Measuring the anterior section of $M_1$ as a difference between two measures from the same point in the anterior part of the dental arch.

When measuring the upper $M_1$ it was not possible to place the instrument parallel to the occlusal plane because the distal contact point is more apically and palatally located than the mesial. The upper $M_1$ were therefore measured with the pointed ends of the instrument, these being placed in the mesio-distal direction with one point at the distal contact point and the other against the mesial surface (along the dotted lines in Fig. 2).

When measuring the anterior sections of the $M_1$ (below called the $M_1$ S) the procedure illustrated in Fig. 2 was followed. Figs. 2 (a) and (b) show the measurement in the two jaws at correct occlusion and Fig. 2 (c) shows the procedure in a case with a rotated upper $M_1$.

## TOOTH WIDTH VALUES FOR DIRECT AND CAST MEASUREMENT

The values obtained were examined for any systematic deviation in respect of the various mensuration procedures. Particular attention was devoted to the accuracy of the direct and cast measurements.

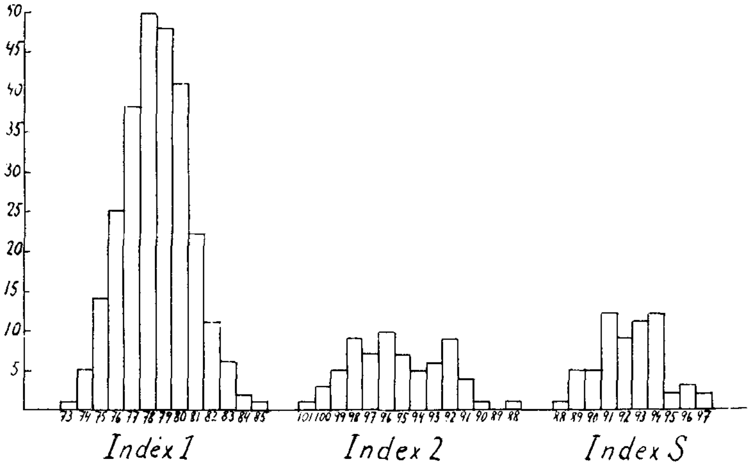


Fig. 3. Histogram showing distribution of different indices.

## SYSTEMATIC DEVIATIONS

Table I shows the systematic deviations between the cast and direct values for the $I_1$, $I_2$ and C in the two age groups examined.

The table shows that the cast values as a rule are the higher. For all teeth except the left $I_1$ (+1) and $I_2$ (+2) the differences are significant, with values lying between $0.03 \pm 0.01$ mm. $I_2$ (2—) and $0.13 \pm 0.01$ mm. C (3+). If the relation between the differences and the corresponding tooth width is calculated, the largest ratios are obtained for the $I_2$ (2+) and C (3+), but the differences are only 1.7 per cent and 1.6 per cent, respectively, of the mean widths of these teeth. From this it is evident that the difference in the values for the two methods is insignificant.

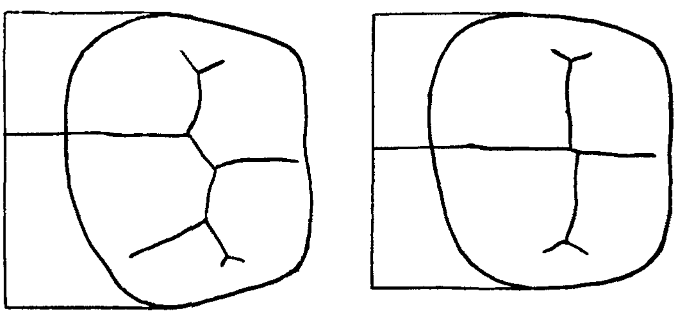

Fig. 4. The fissure between the mesio- and distobuccal cusps of lower $M_1$ is lying more centrally in molars with 2 than in molars with 3 buccal cusps.

**Table I**

Mean differences between cast-measurements and direct measurements for the tooth-breadths of $I_1$, $I_2$ and C

| Tooth | No. | $M \pm \varepsilon(M)$ |
|---|---|---|
| $C\rfloor$ (3 + ) | 171 | + 0.13 ± 0.01 |
| $I_2\rfloor$ (2 + ) | 175 | + 0.11 ± 0.01 |
| $I_1\rfloor$ (1 + ) | 187 | + 0.10 ± 0.01 |
| $\lfloor I_1$ ( + 1) | 190 | + 0.02 ± 0.01 |
| $\lfloor I_2$ ( + 2) | 185 | 0.0 ± 0.01 |
| $\lfloor C$ ( + 3) | 172 | + 0.11 ± 0.01 |
| $C\rceil$ (3 − ) | 190 | + 0.06 ± 0.01 |
| $I_2\rceil$ (2 − ) | 189 | + 0.03 ± 0.01 |
| $I_1\rceil$ (1 − ) | 196 | + 0.05 ± 0.01 |
| $\lceil I_1$ ( − 1) | 193 | + 0.03 ± 0.01 |
| $\lceil I_2$ ( − 2) | 194 | + 0.05 ± 0.01 |
| $\lceil C$ ( − 3) | 189 | + 0.04 ± 0.01 |

## RANDOM DEVIATIONS

The precision of the direct and cast measurements has been calculated from double observations. Duplicate measurements of 27 cases were performed and duplicate casts prepared and measured independently. The presence of proximal fillings, hypoplasias and traumatic injuries was disregarded, all teeth that were sufficiently erupted being measured. In Table II (direct

**Table II**

Standard error of a single observation, $s_i$, for direct measurements (in mm.)

| Tooth | No. | $s_i \pm \varepsilon(s_i)$ | Tooth | No. | $s_i \pm \varepsilon(s_i)$ |
|---|---|---|---|---|---|
| $I_1\rfloor$ (1 +) | 27 | 0.05 ± 0.01 | $\lfloor I_1$ (+ 1) | 27 | 0.07 ± 0.01 |
| $I_2\rfloor$ (2 +) | 26 | 0.05 ± 0.01 | $\lfloor I_2$ (+ 2) | 26 | 0.08 ± 0.01 |
| $C\rfloor$ (3 +) | 23 | 0.05 ± 0.01 | $\lfloor C$ (+ 3) | 25 | 0.04 ± 0.01 |
| $I_1\rceil$ (1 −) | 26 | 0.05 ± 0.01 | $\lceil I_1$ (− 1) | 27 | 0.03 ± 0.00 |
| $I_2\rceil$ (2 −) | 27 | 0.04 ± 0.01 | $\lceil I_2$ (− 2) | 27 | 0.07 ± 0.01 |
| $C\rceil$ (3 −) | 27 | 0.07 ± 0.01 | $\lceil C$ (− 3) | 26 | 0.05 ± 0.01 |

measurement) and Table III (cast measurement) the values are given for the standard error of the single observation, ($S_i$) for all teeth, calculated from the duplicate measurements.

**Table III**

Standard error of a single observation, $s_i$, for cast-measurements (in mm.)

| Tooth | No. | $s_i \pm \varepsilon(s_i)$ | Tooth | No. | $s_i \pm \varepsilon(s_i)$ |
|---|---|---|---|---|---|
| $\underline{I_1\|}$ (1 +) | 26 | 0.09 ± 0.01 | $\underline{\|I_1}$ (+ 1) | 26 | 0.09 ± 0.01 |
| $\underline{I_2\|}$ (2 +) | 26 | 0.11 ± 0.02 | $\underline{\|I_2}$ (+ 2) | 26 | 0.10 ± 0.01 |
| $\underline{C\|}$ (3 +) | 21 | 0.09 ± 0.01 | $\underline{\|C}$ (+ 3) | 24 | 0.09 ± 0.01 |
| $\underline{P_1\|}$ (4 +) | 24 | 0.10 ± 0.01 | $\underline{\|P_1}$ (+ 4) | 25 | 0.10 ± 0.01 |
| $\underline{P_2\|}$ (5 +) | 26 | 0.09 ± 0.01 | $\underline{\|P_2}$ (+ 5) | 25 | 0.08 ± 0.01 |
| $\underline{M_1\|}$ (6 +) | 25 | 0.14 ± 0.02 | $\underline{\|M_1}$ (+ 6) | 25 | 0.16 ± 0.02 |
| $\underline{M_1S\|}$ | 24 | 0.20 ± 0.03 | $\underline{\|M_1S}$ | 24 | 0.14 ± 0.02 |
| $\overline{I_1\|}$ (1 −) | 27 | 0.07 ± 0.01 | $\overline{\|I_1}$ (− 1) | 27 | 0.08 ± 0.01 |
| $\overline{I_2\|}$ (2 −) | 27 | 0.11 ± 0.02 | $\overline{\|I_2}$ (− 2) | 27 | 0.10 ± 0.01 |
| $\overline{C\|}$ (3 −) | 27 | 0.12 ± 0.02 | $\overline{\|C}$ (− 3) | 25 | 0.10 ± 0.02 |
| $\overline{P_1\|}$ (4 −) | 25 | 0.10 ± 0.01 | $\overline{\|P_1}$ (− 4) | 26 | 0.12 ± 0.02 |
| $\overline{P_2\|}$ (5 −) | 24 | 0.11 ± 0.02 | $\overline{\|P_2}$ (− 5) | 24 | 0.15 ± 0.02 |
| $\overline{M_1\|}$ (6 −) | 25 | 0.13 ± 0.02 | $\overline{\|M_1}$ (− 6) | 26 | 0.16 ± 0.02 |
| $\overline{M_1S\|}$ | 24 | 0.19 ± 0.03 | $\overline{\|M_1S}$ | 26 | 0.26 ± 0.04 |

A comparison of the $S_i$ values for the $I_1$, $I_2$ and C by direct and cast measurements is of particular interest, as in the subsequent treatment of the results it is necessary to choose the most accurate values.

Significant differences between $S_i$ for cast and direct measurement were found for the $\underline{I_2|}$ (2), $\underline{|C}$ (+ 3), $\overline{I_2|}$ (2 −), $\overline{|I_1}$ (− 1) and $\overline{|C}$ (− 3); hence for all these teeth lower values of $S_i$ were obtained by direct measurement; that is, the accuracy was greater than for the measurements performed on the casts. For the $\underline{C|}$ (3 +) and $\overline{I_1|}$ (1 +) it is very likely that a similar difference exists. For the other teeth, too, $S_i$ is greater for the cast measurements, but the differences are less than 2.5 times their standard error and consequently may be random. The comparison thus suggests that the direct measurements were generally the more accurate; direct values were therefore used for the $I_1$, $I_2$ and C in the sequal.

On account of the fairly large errors of measurements for $M_1$ S these measures were disregarded in the main investigation.

## THE VARIATION OF SOME INTERMAXILLARY TOOTH WIDTH RATIOS

The relation between the tooth widths of the upper and lower jaws was determined by calculation of indexes between various tooth width sums in the two jaws. The following indices were formed:

*Index 1,* defined as the ratio of the sums of the incisor and canine widths for the upper and lower jaws, multiplied by 100: that is

$$\text{Index } 1 = \frac{I_1 + I_2 + C \text{ (mandible)}}{I_1 + I_2 + C \text{ (maxilla)}} \times 100$$

*Index 2,* defined as the ratio of the sums of the premolar and first molar widths for the upper and lower jaws, multiplied by 100; that is

$$\text{Index } 2 = \frac{P_1 + P_2 + M_1 \text{ (maxilla)}}{P_1 + P_2 + M_1 \text{ (mandible)}} \times 100$$

*Index S,* defined as the ratio of the sums of the incisor, canine, premolar and first molar widths for the upper and lower jaws, multiplied by 100; that is

$$\text{Index S} = \frac{I_1 + I_2 + C + P_1 + P_2 + M_1 \text{ (mandible)}}{I_1 + I_2 + C + P_1 + P_2 + M_1 \text{ (maxilla)}} \times 100$$

In the index calculation only those tooth width aggregates were used in which each tooth unit was represented on at least one side by a tooth far enough erupted and in a sufficiently good condition (no proximal cavities or fillings) to permit measurement of the width.

Table IV gives the number of observations, the means and standard deviations, and the maximum and minimum values for the three indices.

The empirical maximum and minimum values are such as would be expected from the size of the case series. For Index 1, where the number of cases is relatively great, the empirical values are near the theoretical range defined by $M \pm 3 \times$ *standard*

**Table IV**

Means and variability of the investigated tooth-breadth indices

| Index | No. | M ± ε (M) | s ± ε (s) | Empiric max. value | Empiric min. value |
|---|---|---|---|---|---|
| 1 | 264 | 78.5 ± 0.13 | 2.07 ± 0.09 | 84.5 | 73.0 |
| 2 | 68 | 95.3 ± 0.34 | 2.80 ± 0.24 | 100.5 | 88.5 |
| S | 63 | 92.3 ± 0.26 | 2.07 ± 0.18 | 97.5 | 88.0 |
| 1 (*Selmer-Olsen)* | 87 | 78.9 ± 0.25 | 2.37 ± 0.18 | 85.7 | 74.5 |

*deviation,* while for Indices 2 and S the empirical values lie between M ± 2 and M ± 2.5 × *standard deviation.*

The frequency curves for the indices are given in Fig. 3.

For Index 1 the values are comparable with those of *Selmer-Olsen* (personal communication) calculated for the variation in Norwegian Lapps. For both the standard deviation and the means the differences are so small that they might well be due to chance.

The standard deviations calculated directly from the material are, of course, greater than the true values on account of the

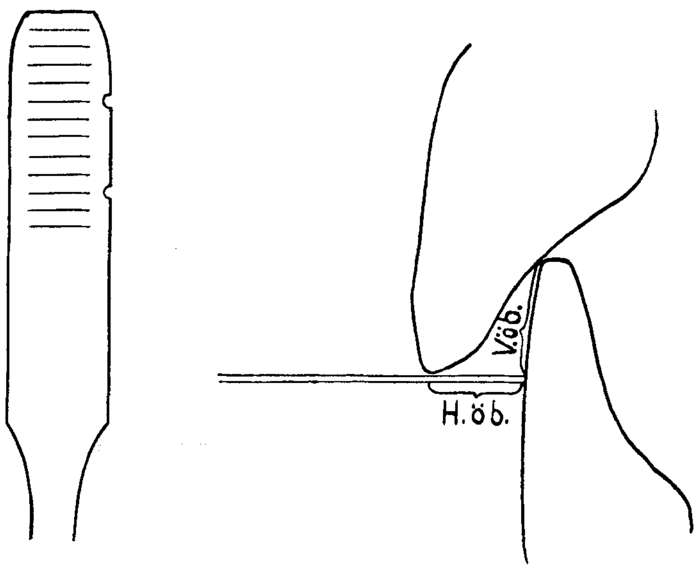


Fig. 5. Measuring of sagittal and vertical overbite (overjet and overbite).

random errors of measurement. By means of the double observations it is possible to calculate the fraction of the standard deviations due to errors in measurement. From the duplicate observations the standard error of the single observation is calculated for each index, after which the corrected or true standard deviations are calculated from the expression

$$S^2 = S_C^2 + S_i^2$$

where S is the observed and $S_C$ the true standard deviation, and $S_i$ the standard error of the single observation.

Table V gives the calculated values of $S_i$ and $S_C$ for the three indices.

**Table V**

Standard errors of a single observation ($s_i$) and corrected standard deviations ($s_c$) for different indices (errors of measurements eliminated)

| Index | $s_i \pm \varepsilon(s_i)$ | $s_c \pm \varepsilon(s_c)$ |
|---|---|---|
| 1 | 0.41 ± 0.06 | 2.03 ± 0.09 |
| 2 | 1.00 ± 0.15 | 2.62 ± 0.22 |
| S | 0.57 ± 0.09 | 1.99 ± 0.16 |

An impression of the magnitude of the variations as expressed by the standard deviations is obtained by calculating the sums of the widths of the maxillary teeth for the following values of the index:

$$M, \; M - 3S_C, \; M + 3S_C,$$

assuming average values for the totals of the mandibular tooth widths (Table VI).

**Table VI**

Calculated distribution of totals of tooth-widths in the upper jaw with average tooth-widths of corresponding teeth in the lower jaw at different index-values (M = average, M ± 3 $s_c$ = average ± 3 × corrected standard dev. from table V)

| | Index-value | | $M - 3s_c$ | M | $M + 3s_c$ |
|---|---|---|---|---|---|
| Index 1 | Lower J. = 36.2 | Upper J. = 50.0 | | 46.2 | 42.8 |
| » 2 | » = 50.1 | » = 43.8 | | 47.7 | 51.7 |
| » S | » = 86.1 | » = 99.7 | | 93.3 | 87.6 |

The differences between the maxillary tooth width totals for the index values $M - 3S_C$ and $M + 3S_C$ — which may be considered as the limiting values of variation — are for

incisors + canines = 7.2
premolars + 1st molars = 7.9
incisors + canines + premolars + 1st molars = 12.1.

These differences are so large that it should be possible to reveal a correlation between the maxilla—mandible tooth width ratio and the tooth alignment or occlusion.

Is there any correlation between Index 1 and Index 2? In other words, are relatively large upper teeth (i.e. compared with the lower teeth) in the maxillary anterior region associated with relatively large upper teeth in the maxillary posterior region; or are large teeth in one region of the maxilla compensated by small teeth in another. Calculation of the correlation between the two indices followed the procedure due to Bravais-Pearson. The occurence of low values of Index 1 and high of Index 2 (= large upper teeth in relation to lower) is denoted as positive. For 62 cases the value obtained for the correlation coefficient was

$$r = + 0.01 \pm 0.13$$

There is clearly no close connection between the two indices. Whether a weak positive or a negative correlation exists it is impossible to decide with so small a case series.

## INTERMAXILLARY TOOTH WIDTH RATIO AND TOOTH POSITION

The intermaxillary tooth width ratio may be expected to influence the tooth alignment or occlusion in the following respects:

(1) Cases with relatively large upper teeth may present different molar occlusion from cases with relatively small upper teeth. If differences in the intermaxillary tooth width ratio are accompanied by such variations in the occlusion, cases of the former type would tend to present a more mesial position of the lower molars in relation to the upper than cases of the latter type. This is not very probable in view of the fact that the first molars are the first of the permanent teeth to occlude. It may

occur, however, through a tendency of the mandible to move forwards in cases with a relatively large maxillary arch, but on the other hand a narrower upper arch would tend to obstruct such displacement.

(2) Cases with relatively large upper teeth may present more pronounced overjet and/or overbite than cases with relatively small upper teeth.

(3) Compared with cases having relatively small upper teeth cases with relatively large upper teeth may present greater crowding or less spacing in the upper than in the lower arch.

The existance of a connection between the intermaxillary tooth width ratio and the tooth position has been studied by calculating the correlation between the tooth width indices and certain characteristics of the tooth alignment and occlusion.

Firstly, the connection was examined in the whole study group that is, in all measurable cases irrespective of tooth position. Secondly, such cases were examined that, from the viewpoint of tooth position, accorded most closely with anatomically correct occlusion.

## INTERMAXILLARY TOOTH WIDTH RATIO AND MOLAR OCCLUSION (WHOLE STUDY GROUP)

Molar occlusion was evaluated at the $M_1$ by determining the mesio-distal distance between the mesio-buccal cusp tips of the upper $M_1$ and the fissure between the mesio- and disto-buccal cusps of the lower $M_1$. Using a sharp lead pencil, the point on the lower arch that was covered by the mesio-buccal cusp of the upper $M_1$ was marked. The distance in a mesio-distal direction between this point and the fissure between the mesio- and disto-buccal cusps of the lower $M_1$ was measured to a tenth of a millimetre. If the reference point of the mandible lay behind that of the maxilla (postnormal occlusion at the $M_1$) the distance was denoted as negative, and in the opposite case (prenormal occlusion at the $M_1$) as positive.

Cases with bilateral extraction of two or more $M_1$ could not of course be included. For the cases where both sides could be measured the mean value has been taken for the molar occlusion. In cases where only one side was measurable the value so obtained has been accepted.

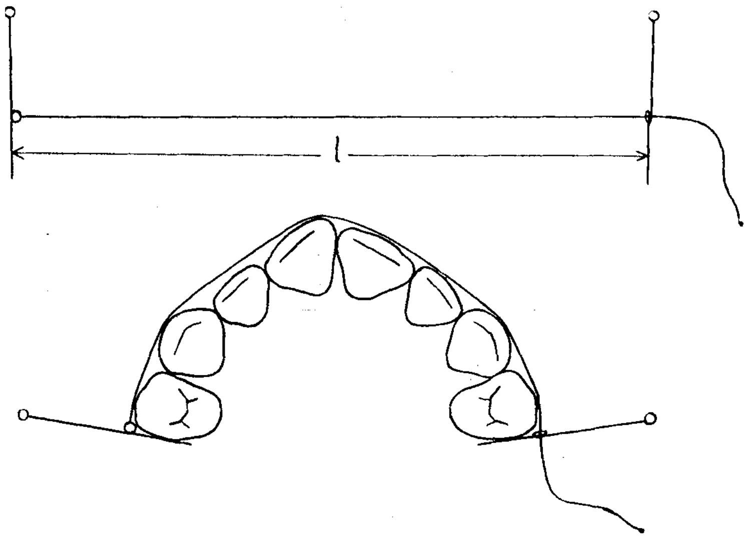


Fig. 6. Measuring relative arch-space as a ratio between the length of thread outside the arch from $P_1$ to $P_1$ and the sum of corresponding tooth-breadths.

One disadvantage of this method of registration lies in the fact that the lower $M_1$ have a varying number of cusps. Fig. 4 illustrates how the fissure between the mesio- and disto-buccal cusps is nearer the centre of the tooth in the four-cusp type. This should influence the value for molar occlusion. Cases with the same general position of the dental arches probably have more negative values for molar occlusion with four cusp $M_1$.

For the 227 cast cases the number of cusps could be determined in 175 $\overline{M_1}|$ (6 —) and 170 $|\overline{M_1}$ (— 6). For the other $M_1$ the teeth were either extracted or so badly damaged by caries or hypoplasias that the number of cusps could not be determined. The distribution of the four and five-cusp types is given in Table VII.

The effect of the number of cusps on the value for molar occlusion was studied by calculating the means of the molar occlusion for cases with mandibular $M_1$ having 3 and 2 buccal cusps. The means are

for the right side: $-0.39 \pm 0.16$ mm (148 cases) and
$-0.81 \pm 0.34$ mm (31 cases); and

for the left side: $-0.02 \pm 0.18$ mm (147 cases) and
$-0.44 \pm 0.27$ mm (34 cases).

Table VII

Distribution of cases with different numbers of cusps for lower $M_1$

| Cusp-number | Right $M_1$ | | Left $M_1$ | |
|---|---|---|---|---|
| | No. | In per cent | No. | In per cent |
| 5 cusps (3 bucc. and 2 ling.) | 141 | 80.6 ± 3.0 % | 134 | 78.8 ± 3.1 % |
| 5 » (2 » » 3 » ) | 1 | 0.6 ± 0.6 % | — | — |
| 4 » (2 » » 2 » ) | 31 | 17.7 ± 2.9 % | 31 | 20.0 ± 3.1 % |
| 6 » (3 » » 3 » ) | 2 | 1.1 ± 0.8 % | 2 | 1.2 ± 0.8 % |
| Total | 175 | 100.0 per cent | 170 | 100.0 per cent |

In this calculation the cases where the number of cusps could be determined only on one side were assumed to be symmetrical. This may be justified by the fact that of the 157 cases of which the number of cusps could be determined bilaterally only 9 presented a difference in number of buccal cusps on the left and right sides.

The differences between the means for cases with 3 and 2 buccal cusps are:

| Left side | Right side |
|---|---|
| $+ 0.42 \pm 0.38$ mm | $+ 0.42 \pm 0.32$ mm resp. |

The standard errors in these differences are so great that it is impossible to decide whether the number of cusps has any influence on the values for molar occlusion. The differences certainly lie in the expected direction, but they might very well be due to chance.

This calculation thus provides no definite indication of the extent of the disturbing effect of the varying number of cusps on the determination of the molar occlusion. If this disadvantage (which in all probability is insignificant) is weighed against the advantage of being able to perform direct measurement of the deviation from the normal, or anatomically correct occlusion at the $M_1$, the method used is probably to be preferred to any other.

The correlation between the Index S (low values with relatively large upper teeth denoted as positive) and the molar occlusion was calculated in 62 cases (all those cases where Index S and the molar relation could be determined). The correlation coefficient was:

$$\text{Index S} - \text{molar occlusion} \quad r = + 0.06 \pm 0.13$$

The value shows that there is no strong correlation, but the standard error is so large that it is impossible to decide whether or not a weaker correlation exists.

### INTERMAXILLARY TOOTH WIDTH RATIO AND OVERJET AND OVERBITE (WHOLE STUDY GROUP)

The overjet (h. ob) was determined for the $I_1\rfloor$ (1 +) and $\lfloor I_1$ (+ 1) and is defined as the mean of the two distances between the buccal surfaces of the lower incisors to the midpoints of the incisal edges of the right and left $I_1$. The distances are measured parallel to the occlusal plane and perpendicular to the dental arch at the measuring points. The measurements were performed with a thin metal spatula calibrated in millimetres, the point of which was ground (Fig. 5 (a)).

As Fig. 5 (b) illustrates, the spatula was placed with the millimetre scale against the mandible, the overjet being measured to one half millimetre.

Overbite (v. ob) was also determined at the $I_1$, and is defined as the mean of the two distances between the lower incisal edges and the points on these teeth from which the overjet was measured (Fig. 5 (b)). The distance was measured with a slide guage to a tenth of a millimetre.

For 62 cases (all the cases where Index S, overjet and overbite could be found) the correlation coefficients were

$$\text{Index S — overjet} \quad r_1 = 0.06 \pm 0.13$$
$$\text{Index S — overbite} \quad r_2 = 0.09 \pm 0.13$$

(Relatively low values of Index S and high values for the overbite have been denoted as positive.)

From these coefficients the same inferences are to be drawn as from the coefficient between Index S and molar occlusion. There appears to be no strong correlation, but whether weaker relationship exists cannot be decided.

### INTERMAXILLARY TOOTH WIDTH RATIO AND THE DIFFERENCES IN RELATIVE DENTAL ARCH SPACE IN UPPER AND LOWER JAWS

The dental arch spacing in relation to the widths of the teeth was studied by a method described in a previous paper (1942).

The dental arch spacing was examined for a segment of the arch anterior to the most distal points of the $P_1$. A thread was held taut along the external perimeter of the dental arch at the level of the contact points, from the $P_1$ on the left to the same tooth on the right. The relative tooth spacing (T) is defined as the ratio of the length L of this perimeter to the total tooth widths of the $I_1$, $I_2$, C and $P_1$ (S) (Fig. 6). In later work another method has been used, making it possible to measure crowding or spacing in different segments of the arch (1948, 1951).

The correlation between Index S and the differences between the maxillary and mandibular relative dental arch spaces was calculated. Only the cases where the Index S could be found and where all the teeth from the $I_1$ to the $M_2$ were present (erupted or visible as protruberances on the alveolar process) were included. Low values of Index S and differences showing greater crowding in the upper than in the lower arch were denoted as positive.

For 57 cases the correlation coefficient was

Index S — diff. in crowding-spacing $r = + 0.41 \pm 0.11$.

The value of the coefficient is significant and indicates that cases with large maxillary (in relation to mandibular) teeth present a tendency to greater crowding (or less spacing) in the maxilla than in the mandible.

An explanation of this correlation is presented in the paper mentioned above, where it was shown that in jaws with large teeth there is a greater tendency to crowding than in jaws with small teeth, which instead have a tendency to overspacing. This may be accounted for by a rather free combination of specific genetic factors influencing the size of the jaw and the teeth, so that a predisposition to large or small teeth is to some extent associated randomly with a predisposition to large and small jaws. On the basis of this hypothesis it might be possible to explain the connection between Index S and the differences in relative dental arch spacing. Cases of relatively larger teeth in one jaw than in the other should be more likely to produce greater crowding in the former than in the latter jaw.

Other possible factors are forces of occlusion in mastication, and pressure of the lips and tongue, all of which probably contribute to an individual adjustment of the teeth to a state of occlusion in equilibrium with the obtaining intermaxillary tooth width ratio.

## INTERMAXILLARY TOOTH WIDTH RATIO AND TOOTH POSITION IN CASES WITH VERY NEARLY ANATOMICALLY CORRECT OCCLUSION

By normal or anatomically correct occlusion is meant functionally ideal occlusion. The following rules are generally recognized at the adult stage:

(1) The teeth (32 in number) form regular arches in both jaws, with contact between them but no crowding, and with defined points in the mesio-distal direction.

(2) On biting together the upper teeth meet the lower labially and bucally. In the anterior region there is moderate overbite of between 1 and 3 mm. In the premolar-molar region the upper palatinal cusps intercuspidate with the lower buccal and lingual cusps. Double antagonism occurs between all teeth except the lower $I_1$ and the upper $M_3$, each maxillary tooth occluding with the corresponding and the adjacent mandibular teeth, counting towards the mid-line.

(3) In articulation there is so-called balanced occlusion; that is, in incisal and lateral occlusion there is smooth contact between the arches anteriorly and in both lateral regions.

Since this conception of the norms is the ideal it is hardly to be expected that it will be fully realized in actual cases. For the subjects under study who had not reached the full adult stage, the third molars had of course not yet erupted. Moreover, according to *Campbell* (1925), *Friel* (1927), *Schwarz* (1936) one cannot expect double antagonism in the premolar region, as this is not as a rule found before the full adult stage and then as a result of abrasive grinding. A further age factor that accounts for deviation from the ideal is that shedding is in many cases not complete, or only just so. In the latter case there is likely to be small spaces between the teeth — especially in the premolar region —, which is in accord with the fact that the permanent teeth in this region are narrower than their predecessors in the deciduous dentition.

Even if these age factors are taken into account and anatomically correct occlusion is less strictly defined, it is impossible to find in the material any case that fulfills exactly all of the requirements in respect of tooth alignment and occlusion. The articulation has not been examined. In the cases most closely approaching the ideal there are small deviations in the form of slight rotation of single teeth, slight crowding or overspacing. Between these cases and those with more pronounced malposition the boundary is fluid. It is therefore very difficult to give any frequency figures for cases that may be considered as normal. The percentage of normal cases will depend on the degree of malocclusion admissible in the various respects. It was possible to choose 9 cases of the 227 (7 boys and 2 girls) for which the casts prepared had insignificant deviations. Table VIII gives the values for molar occlusion, overbite and overjet relative dental arch spacing (+ signifying a tendency to the formation of spaces and — a tendency to crowding) and the Index S in these cases; Table IX, for the sake of comparison, gives the distribution of the whole study group for the same values. The Index S has been calculated for all normal cases — that is, even those that present bilateral carious lesions on proximal surfaces of one or more teeth (Cases 39, 47, 206 and 307).

**Table VIII**

Molarocclusion, overjet and overbite, relative arch-space (— = tendency to crowding, + = tendency to spacing) and Index S in 9 cases with »anatomically correct occlusion» (measures in mm.)

| Case no. | Molarocclusion | | Over-jet | Over-bite | Relative arch-space | | | | Index S |
|---|---|---|---|---|---|---|---|---|---|
| | right | left | | | Upper | jaw | Lower | jaw | |
| 25 | — 0.5 | — 0.4 | 3.0 | 2.9 | 1.11 | — | 1.07 | — | 93.06 |
| 39 | — 0.6 | — | 2.3 | 2.6 | 1.10 | — | 1.09 | — | 86.93 |
| 42 | 0.0 | 0.0 | 1.5 | 2.1 | — | + | 1.14 | + | — |
| 47 | + 0.4 | 0.0 | 2.8 | 2.6 | 1.18 | + | 1.11 | — | 92.09 |
| 206 | 0.0 | 0.0 | 1.0 | 2.3 | 1.12 | — | 1.11 | — | 93.33 |
| 334 | 0.0 | 0.0 | 2.0 | 2.7 | 1.11 | — | 1.08 | — | 93.02 |
| 336 | + 2.3 | + 1.2 | 1.0 | 3.0 | 1.12 | — | 1.08 | — | 93.10 |
| 307 | — 0.6 | — 1.0 | 2.5 | 3.0 | 1.10 | — | 1.06 | — | 91.15 |
| 183 | + 1.6 | + 2.0 | 2.5 | 2.2 | 1.16 | + | 1.10 | + | 92.62 |

Table VIII shows that for the normal cases relatively small variations of indices were recorded. In one case only (No. 39) is there any appreciable deviation from the others. The number of cases is too small, however, to decide whether any consider-

**Table IX**

Means (M), standard deviations (s) and skewness (sk) with their standard errors for molarocclusion, overjet, overbite (in mm.) relative arch-space and index S in the total number of cases. Prenormal molarocclusion (lower to upper) has a positive and post-normal a negative sign.

| | Molar-occlusion | | Incisor relation-ship | | Relative arch-space | | Index S |
|---|---|---|---|---|---|---|---|
| | right | left | overjet | overbite | upper jaw | lower jaw | |
| No. | 184 | 186 | 224 | 222 | 137 | 156 | 63 |
| $M \pm \varepsilon(M)$ ........ | $-0.43 \pm 0.16$ | $-0.06 \pm 0.16$ | $2.91 \pm 0.12$ | $2.85 \pm 0.09$ | $1.133 \pm 0.005$ | $1.114 \pm 0.004$ | $92.27 \pm 0.26$ |
| $s \pm \varepsilon(s)$ ........ | $2.08 \pm 0.11$ | $2.10 \pm 0.11$ | $1.75 \pm 0.08$ | $1.39 \pm 0.07$ | $0.053 \pm 0.003$ | $0.044 \pm 0.003$ | $2.07 \pm 0.18$ |
| $Sk \pm \varepsilon(Sk)$ ...... | $-0.64 \pm 0.18$ | $-1.40 \pm 0.18$ | $+1.47 \pm 0.16$ | $+0.04 \pm 0.16$ | $-0.11 \pm 0.21$ | $+0.68 \pm 0.20$ | $+0.22 \pm 0.31$ |
| Empiric max. value ..... | + 6.5 | + 6.5 | + 10.75 | + 6.5 | 1.30 | 1.30 | 97.5 |
| Empiric min. value ...... | — 8.0 | — 9.5 | — 0.75 | — 0.75 | 0.94 | 1.02 | 88.0 |

able difference exists between normal cases selected on the basis described and other cases.

In this respect the values for the same relations (p. 2) obtained with *Tonn's* normal group may serve as a guide. As they were not calculated in index form they should be multiplied by 100 so as to be comparable with the figures obtained in the present investigation. The difference D between the standard deviations for Index S for the whole of the present study group and for Tonn's normal group is

$$D = + 0.37 \pm 0.28$$

The difference is not significant and the question of any difference in the variation of Index S between the normal cases and others must be left open.

For the normal cases no connection can be established between the Index S and any of the characteristics of tooth position studied. If the cases in question had been characterized by constant molar occlusion and perfectly regular arches a direct connection would have existed between the Index S and both overjet and overbite. In the cases that best fulfilled the requirements of the ideal occlusion there appears, however, to be such variation of the molar occlusion and the relative dental arch spacing that any such connection is impossible to demonstrate.

An analysis of the values for molar occlusion, overbite and relative dental arch spacing for the whole study group in Table IX does not come within the scope of this paper. It will suffice to mention that the standard deviations for molar occlusion, overjet, overbite and relative dental arch spacing in the lower jaw cannot be used in the same way as for a normal curve, as for these properties there is a significant skewness in distribution. The values obtained for the skewness (sk) are given in Table IX.

## INTERMAXILLARY TOOTH WIDTH RATIO AND THERAPY IN MALOCCLUSION

The present investigation has confirmed the opinion frequently voiced in current orthodontic literature that changes in the intermaxillary tooth width relation play a subsidiary role in the etiology of malocclusion. This does not, however, mean that the factors in question are devoid of interest in the treatment of malocclusion.

*Strang* (1933) states that cases with disharmony between upper and lower tooth widths of such a degree that normal occlusion is prevented is extremely rare. In such cases, however, a certain degree of crowding or over-spacing in one jaw becomes inevitable.

*Dewey-Andersson* (1935) maintains also that in such extreme cases one must be content with a modified aim of treatment. It must be accepted that in the completed case there will be either slight crowding or over-spacing in one of the jaws, or else exceptionally large or small overbite. *Körbitz* (1940), *Neff* (1949) and *Steadman* (1949) also stress the association between tooth-width-variations and the overbite.

*Tonn* (1937) advocates, in addition to the above measures recommended by Strang and Dewey-Andersson, interproximal grinding or extraction of premolars in the jaw containing the relatively large teeth. For other cases a slight displacement of arch relationship is suggested.

The author would stress the difficulties mentioned by these workers. They certainly do not arise in all cases of tooth-width disharmony. If the variation in question is compensated by corresponding deviations in the sagittal relation of the teeth, and/or overbite, no therapeutical problem should present itself. The investigation has, however, shown that such compensation is not a regular phenomenon. Instead there appear, parallel with the changes in tooth width index, differences in the degree of crowding between the jaws.

## SUMMARY

The article reports an investigation on the variation in the intermaxillary tooth width ratio, performed on an unselected study group consisting of 319 children of 13 years of age.

For 227 of these plaster casts were prepared from hydrocolloid impressions. The dispersion was determined for three indices in respect of the total widths of various tooth groups, viz,

$$(1)\ \frac{I_1 + I_2 + C\ \text{(mandible)}}{I_1 + I_2 + C\ \text{(maxilla)}} \times 100$$

$$(2)\quad \frac{P_1 + P_2 + M_1 \ (\text{maxilla})}{P_1 + P_2 + M_1 \ (\text{mandible})} \times 100$$

$$(3)\quad \frac{I_1 + I_2 + \ldots + M_1 \ (\text{mandible})}{I_1 + I_2 + \ldots + M_1 \ (\text{maxilla})} \times 100$$

For each index the error of measurement was determined on the basis of the differences between double determinations on the same subject. The variations revealed in the whole study group could thus be reduced with respect to the effect of random errors of measurement, and the residual "biological" dispersion could be calculated for the indices in question (Table V). These calculations show that the biological dispersion in the tooth width ratio is great enough to have an appreciable influence on the positions of the teeth.

An effect on the tooth alignment or on the overbite and overjet is particularly likely. For the sake of completeness the connection between the intermaxillary tooth width variation and the molar occlusion was also determined.

Correlation coefficients were calculated for the characteristics mentioned. The only significant connection was between the tooth width ratio and the difference between the degree of crowding in the maxilla and mandible ($r = + 0.41 \pm 0.11$). This means that if the upper teeth are unusually large compared with the lower there is a tendency to greater crowding in the maxilla compared with the mandible, while relatively small maxillary teeth are accompanied by the contrary tendency.

The importance to therapy of anomalies in the tooth width ratio is discussed. In a majority of cases the variation in the tooth width ratio probably plays a minor role. In cases of extreme values, however, the treatment must be modified accordingly, and it may then be of value to determine at the outset the deviation from the average intermaxillary tooth width ratio.

## RÉSUMÉ

Dans l'ouvrage présent, l'auteur a rendu compte d'une investigation de la variation des relations intermaxillaires de largeur dentaire exécutée sur des sujets non-choisis, comprenant 319 enfants âgés de 13 ans. Des moules de plâtre ont été faits

de 227 enfants après empreinte avec une pâte de moulage hydrocolloidale. La dispersion a été déterminée pour 3 indices comprenant les largeurs dentaires totales des dents suivantes:

1. $\frac{I_1 + I_2 + C \text{ (mâchoire inférieure)}}{I_1 + I_2 + C \text{ (mâchoire supérieure)}} \times 100$

2. $\frac{P_1 + P_2 + M_1 \text{ (mâchoire supérieure)}}{P_1 + P_2 + M_1 \text{ (mâchoire inférieure)}} \times 100$

3. $\frac{I_1 + I_2 + \ldots + M_1 \text{ (mâchoire inférieure)}}{I_1 + I_2 + \ldots + M_1 \text{ (mâchoire supérieure)}} \times 100$

Pour chaque index les erreurs de mesure ont été déterminées sur la base des différences entre des observations doublées du même sujet. On a ainsi pu réduire la variation trouvée chez la matière entière en éliminant l'effet d'erreurs fortuites et a pu estimer la dispersion "biologique" restante pour les indices en cause (tableau V). Ces calculs montrent que la dispersion biologique en les relations de largeur dentaire est si grande que la position dentaire en doit être influencée considérablement. Il se peut que ces variations puissent influer sur la position dentaire en ce qui concerne la super-occlusion (horisontale et verticale) et le degré d'étroitesse dans les mâchoires supérieures et inférieures et, éventuellement, sur l'occlusion molaire. Le rapport entre les caractéristiques en question a été fixé par des calculs de correlation.

A un égard seulement l'on a obtenu un rapport significatif, c. à d. entre la relation de largeur dentaire et la différence entre les mâchoires supérieures et inférieures en ce qui concerne le degré d'étroitesse ($r = + 0.41 \pm 0.11$). Si les dents de la mâchoire supérieure sont exceptionellement grandes par rapport à celles de la mâchoire inférieure, il se produit une tendance d'agrandissement de l'étroitesse (ou espacement diminué) dans la mâchoire supérieure, tandis que des dents supérieures exceptionellement petites par rapport aux dents inférieures produisent une différence contraire en ce qui concerne le degré d'étroitesse entre les mâchoires.

L'importance pour la thérapie des anomalies dentaires a été discutée. Dans la plupart des cas, la variation de la relation de largeur des dents semble jouer un rôle peu important. En des cas avec des valeurs extrêmes, la thérapie doit pourtant être modifiée en en tenant compte, et il peut donc avoir de l'importance de déterminer, dès le commencement du traitement, quel est l'écart de la relation de largeur intermaxillaire moyenne.

## ZUSAMMENFASSUNG

In vorliegender Arbeit wird über eine Untersuchung von der Variation bei intermaxillaren Zahnbreiteverhältnissen Bericht erstattet, die an einem nicht auserwählten Material von 319 13-jährigen Kindern ausgeführt wurde. Von 227 Kindern wurden Gipsmodelle nach Abdrücken aus hydrokolloidalen Abdruckmassen hergestellt. Die Streuung wurde für 3 Indices bestimmt, die die Zahnbreitesummen folgender Zähne umfassen:

1. $$\frac{I_1 + I_2 + C \text{ (Unterkiefer)}}{I_1 + I_2 + C \text{ (Oberkiefer)}} \times 100$$

2. $$\frac{P_1 + P_2 + M_1 \text{ (Oberkiefer)}}{P_1 + P_2 + M_1 \text{ (Unterkiefer)}} \times 100$$

3. $$\frac{I_1 + I_2 + \ldots + M_1 \text{ (Unterkiefer)}}{I_1 + I_2 + \ldots + M_1 \text{ (Oberkiefer)}} \times 100$$

Für jeder Index wurden die Messungsfehler auf Basis der Unterschiede zwischen paarweisen Beobachtungen an dem gleichen Individuum bestimmt. Dadurch konnte die gefundene Variation des ganzen Materials durch Eliminieren des Effekts zufälliger Messungsfehler reduziert werden, und die restierende "biologische" Streuung für die entsprechende Indices berechnet werden (Tabelle V). Diese Berechnungen zeigen, dass die biologische Streuung der Zahnbreiteverhältnisse so gross ist, dass die Zahnstellung dadurch merkbar beeinflusst werden muss.

Diese Variationen könnten die Zahnstellung betreffs des Überbisses (horizontal und vertikal) und des Grades des Engstandes im Ober- und Unterkiefer sowie eventuell der Molarenokklusion beeinflussen. Der Zusammenhang zwischen den entsprechenden Merkmalen wurde durch Korrelationsberechnungen bestimmt. Nur in einer Hinsicht wurde ein signifikativer Zusammenhang

erhalten, nämlich zwischen dem Zahnbreiteverhältnis und dem Unterschied zwischen Ober- und Unterkiefer in dem Engstandsgrad ($r = + 0.41 \pm 0.11$). Wenn die Zähne des Oberkiefers aussergewöhnlich gross sind im Verhältnis zu den Zähnen im Unterkiefer, entsteht eine Tendenz zu grösserem Engstand (oder zu weniger ausgesprochener lichten Verteilung) im Ober- als im Unterkiefer, während aussergewöhnlich kleine Oberkieferzähne im Verhältnis zu den Unterkieferzähnen eine entgegengesetzte Differenz in dem Engstandsgrad zwischen den Kiefern ergeben.

Die Bedeutung der Therapie bei Zahnstellungsanomalien ist diskutiert worden. In den meisten Fällen dürfte die Variation in der Zahnbreiterelation eine untergeordnete Rolle spielen. Bei Fällen mit extremen Werten muss doch die Therapie mit Rücksicht hierauf modifiiert werden, und es kann dann von Bedeutung sein, schon zu Beginn der Behandlung zu bestimmen, wie gross die Abweichung von einer intermaxillaren Zahnbreiterelation durchschnittlicher Grösse ist.

## REFERENCES


*Campbell, T. D.*, 1925: Dentition and Palate of the Australian Aboriginal. — Univ. of Adelaide, Publ. of the Keith Sheridan Foundation. Nr 1.

*Dewey, Martin, & George M. Anderson*, 1935: Practical Orthodontia. — St. Louis, p. 72.

*Friel, Sheldon*, 1927: Occlusion. Observations on its Development from infancy to Old Age. — Internat. J. of Orthod. *13*, p. 322.

—»— 1954: The Development of Ideal Occlusion of the Gum Pads and the Teeth. — Am. J. of Orthod. *40*, p. 196—227.

*Korkhaus, Gustav*, 1930: Orthodontische Diagnostik. — Fortschr. der Zahnheilk. *6*, p. 757.

*Körbitz, G., jun.*, 1940: Biologie im Dienste der Kieferorthopädie. — Zschr. f. Stom. *38*, p. 50.

*Lundström, Anders*, 1942: Äro trångställningar vanligare hos fall med stora än hos fall med små tänder? — Sv. Tandläk.-Tidskr. *35*, p. 399.

—»— 1943: Intermaxillära tandbreddsförhållanden och tandställningen. — Svensk Tandläk.-Tidskr. *36*.

—»— 1951: The Ætiology of Crowding of the Teeth and Its Bearing on Orthodontic Treatment. — Transactions of European Orthod. Soc.

—»— 1952: On the Correlation Between the Toothsize and the Irregularities of the Teeth. — Archives of Orthodontics, *1*.

*Moorrees, C. F.*, and *Reed, R. B.*, 1954: Biometrics of Crowding and Spacing of the Teeth in the Mandible. — Am. J. Phys. Anthrop., *12*, p. 77—88.

*Neff, C. V.*, 1949: Tailored occlusion with the anterior coefficient. — Am. J. o. Orthod. *35*, p. 309.

*Ritter, Reinhold*, 1933: Untersuchungen über die mesio-distalen Grössenverhältnisse der Zähne des Oberkiefers zu denen des Unterkiefers. — Fortschr. der Orthod. *3*, p. 261.

*Seipel, C. M.*, 1946: Variation of Tooth-Position. — Svensk Tandläk.-Tidskr., *39*. Supplement.

*Selmer-Olsen, Reidar*, 1949: An Odontometrical Study on the Norwegian Lapps. — Thesis publ. by Det Norske Videnskaps-Akademi, Oslo — J. Dybwad, Oslo, p. 68.

*Steadman, S. R.*, 1949: Predetermining the overbite and overjet. — Angle Orthod. *19*, p. 101.

*Strang, Robert H. W.*, 1933: A Text-Book of Orthodontia. Philadelphia, p. 110.

*Tonn, P.*, 1937: Über die mesio-distalen Zahnbreitenrelationen der Zähne des Oberkiefers zu den entsprechenden des Unterkiefers bei normalen und anormalen Okklusion. — Diss. Berlin.

*Young, J. Lowe*, 1923: Rational Treatment of Infraclusion. Internat. J. of Orthod. *9*, p. 886.

Address:

*Royal School of Dentistry*
*Holländargatan 17*
*Stockholm 3*