Alveolar Arch Dimensions and Occlusal Traits

An Epidemiologic Study

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A statistical evaluation of dentoalveolar relationships in a cross-section of young Finnish adults, finding little relationship between occlusal anomalies and dimensions of the alveolar arches.

KEY WORDS: • ALVEOLAR ARCH • OCCLUSION •

Anthropometric measurements of the dimensions of maxillary and mandibular arches have been recorded in several populations (KOSKI 1948, TAYLOR 1962, AND SLAGSVOLD 1971). Changes in these dimensions during growth are also well documented (MOORREES 1959, KNOTT 1961 AND 1972, LEBRET 1962, LAVELLE ET AL., 1970, BJÖRK AND SKIELLER 1974, MOYERS ET AL. 1976). Less is known about the variation in alveolar arch dimensions and the correlations between different dimensions in young adults.

When characteristics and etiology of different types of occlusal anomalies have been studied, the investigations of the form of skeletal structures have concentrated on cephalometric evaluations of craniofacial proportions in the sagittal plane.

In the few studies of possible associations between linear dimensions and occlusal anomalies, the results have been somewhat conflicting. WOOD (1971) reported that measurements of arch width for Class I did not differ from those for a random sample, while HERREN AND JORDI-GUILLORD (1973) found the upper arches of ideal occlusions to be wider than those for all classes of anomalies.

STAAB (1962) stated that the form of the palate was associated with the antero-posterior relationship of the mandible to the maxilla. SOLOW (1966) investigated the pattern of associations among components of the craniofacial complex and found, on the one hand, associations reflecting compensatory dentoalveolar adaptation to the intermaxillary relations, and on the other hand, associations indicating that such compensations were insufficient.

The aims of this study were —

- to investigate correlations among different dimensions of the alveolar arch in the maxilla and mandible, and
- to determine the relationships between alveolar arch dimensions and occlusal traits in males and females.

— Materials and Methods —

The original sample included 451 undergraduate students at Jyvškylä University in middle Finland. After exclusion of subjects with extensive restorations, marked malposition of teeth due to crowding, or extraction of several adjacent teeth in lateral segments, the final sample included 251 subjects. A more detailed description of the sample and measurement methodology will be found on page 226.

Occlusal anomalies were recorded by the same examiner in maximum intercuspal position, using the method of Bjork, Krebs and Solow (1964) with slight modifications.

Distal and mesial molar occlusion were both recorded in bilateral deviations of maxillary first molars with at least one half cusp width mesial or distal deviation from normal occlusion.

Overjet was measured as the horizontal distance (mm) parallel to the occlusal plane from the most labial point of the maxillary right central incisor to the corresponding point on the antagonist mandibular incisor.

Overbite was measured vertically (mm) from the incisal edge of the maxillary right central incisor to the anterior edge of the mandibular right central incisor.

Lateral open bite was recorded for vertical spaces of at least 1mm between the maxillary and mandibular bicuspids and/or molars.

Crossbite was recorded where the buccal cusp of one or more maxillary bicuspids and/or molars was buccal to the maximum height of an opposing buccal cusp.

Scissors bite (buccal crossbite) was recorded where the lingual cusp of one or more maxillary bicuspids and/or molars was buccal to the maximum height of the opposing buccal cusp.

Correlation coefficients were calculated separately for males and females for various dimensions both between and within the maxillary and mandibular arches as well as between different types of occlusal anomalies. Because no statistically significant differences were found between sexes, the results were pooled. Partial correlation coefficients were also calculated among the variables within each group.

— Results —

The correlation coefficients for widths and depths of the maxillary alveolar arch and corresponding mandibular dimensions (Table 1) showed that the correlation was highest at the level of first bicuspids and first molars. While statistically significant, all correlations except at the region of the permanent first molars were rather weak.

Correlations between different segments for each alveolar arch dimension

Table 1

Correlations between Corresponding Maxillary and Mandibular Arch Dimensions
N=251

Dimension	r
Arch Width at Level of —	
Cuspids	0.18
First Bicuspids	•0.39
Second Bicuspids	•0.24
First Molars	•0.56
Arch Depth at Level of —	
Cuspids	•0.25
First Bicuspids	•0.29
Second Bicuspids	•0.25
First Molars	•0.50

• $p<0.001$

(Table 2) showed that the correlations for all dimensions were highest in the posterior regions, lower toward the anterior, and clearly lowest at the level of the cuspids. For each dimension the correlation between cuspids and other pairs of teeth was progressively greater from the level of the first molars toward the anterior part of the arch, even clearly higher at the level of first bicuspids than at second bicuspids.

Correlations between different segments were highest for maxillary arch width, and progressively less for maxillary arch depth, mandibular arch width and depth, and palatal height.

Table 3 shows the correlation coefficients between different types of occlusal anomalies. Distal molar occlusion was most often combined with extreme maxillary overjet. Distal molar occlusion was slightly correlated positively with anterior deep bite and "scissors" bite, while distal occlusion was slightly correlated negatively with negative overjet and crossbite.

Mesial molar occlusion was most often combined with a corresponding sagittal anomaly in the anterior segment, the correlation coefficient between mesial occlusion and negative overjet being 0.67. Mesial molar occlusion was also positively

Table 2

Correlations for Dimensions in Different Arch Segments

	Corresponding Dimension at the Level of:			
	First Molars	Second Bicuspids	First Bicuspids	Cuspids
Maxillary Width Between —				
First Molars	1.00	▪0.83	▪0.81	▪0.59
Second Bicuspids	–	1.00	▪.82	▪0.56
First Bicuspids	–	–	1.00	▪0.72
Maxillary Depth at the Level of —				
First Molars	1.00	▪0.87	▪0.74	▪0.47
Second Bicuspids	–	1.00	▪0.82	▪0.49
First Bicuspids	–	–	1.00	▪0.63
Palatal Height at the Level of —				
First Molars	1.00	▪0.77	▪0.40	•0.16
Second Bicuspids	–	1.00	▪0.73	▪0.36
First Bicuspids	–	–	1.00	▪0.66
Mandibular Width Between —				
First Molars	1.00	▪0.82	▪0.68	▪0.51
Second Bicuspids	–	1.00	▪0.73	▪0.39
First Bicuspids	–	–	1.00	▪0.58
Mandibular Depth at the Level of —				
First Molars	1.00	▪0.73	▪0.56	▪0.34
Second Bicuspids	–	1.00	▪0.70	▪0.42
First Bicuspids	–	–	1.00	▪0.52

• $p<.01$ ▪ $p<.001$

Table 3

Correlation Coefficients Between Types of Occlusal Anomalies

	1	2	3	4	5	6	7	8	9
1 Distal Molar Occlusion	+1.00	• −0.94	■ +0.45	• −0.08	■ +0.16	−0.06	−0.06	• −0.08	• −0.08
2 Mesial Molar Occlusion	–	+1.00	−0.05	■ +0.67	−0.04	■ +0.45	−0.03	■ +0.24	−0.01
3 Extreme Maxillary Overjet	–	–	+1.00	−0.04	+0.04	+0.04	−0.03	−0.07	+0.05
4 Mandibular Overjet	–	–	–	+1.00	−0.03	■ +0.69	−0.03	■ +0.29	−0.05
5 Incisor Deep Bite	–	–	–	–	+1.00	−0.04	−0.02	• −0.08	● +0.14
6 Incisor Open Bite	–	–	–	–	–	+1.00	+0.03	■ +0.26	−0.07
7 Lateral Open Bite	–	–	–	–	–	–	+1.00	+0.05	+0.03
8 Crossbite	–	–	–	–	–	–	–	+1.00	-0-
9 Scissors Bite	–	–	–	–	–	–	–	–	+1.00

• $p \leq .05$ ● $p \leq .01$ ■ $p \leq .001$

correlated with anterior open bite and crossbite. Correlations between extreme maxillary overjet and other occlusal anomalies were low in all cases except distal molar occlusion. The highest correlation between different types of occlusal anomalies was 0.69, between anterior openbite and negative overjet, which was also correlated with crossbite. In addition to the correlations already mentioned, anterior openbite was slightly correlated positively with crossbite.

Partial correlation coefficients between alveolar arch dimensions and molar occlusion (Table 4) showed a trend toward a slightly narrow maxillary arch and slightly long mandibular arch in the bicuspid region of subjects with distal molar occlusion. In cases of mesial molar occlusion, a tendency toward a slightly narrow and short mandibular alveolar arch could be seen at the level of the second bicuspids.

For correlations between alveolar arch dimensions and incisor occlusion (Table 5), large overjet was slightly correlated negatively with widths of the maxillary and mandibular arches between the first bicuspids and depth of the mandibular arch at the level of the second bicuspids, and positively with palatal height at the cuspid level.

Large overbite was slightly correlated with width of the maxillary arch between the second bicuspids and the cuspids, but not between the first molars and first bicuspids, and it was also slightly correlated negatively with palatal height at the level of the first molars and cuspids.

The highest values for partial correlation coefficients between alveolar arch dimensions and different occlusal anomalies were found in connection with transverse occlusal anomalies (Table 6). Crossbite was correlated with narrowed maxillary and broadened mandibular arch; palatal height was also slightly higher in the posterior part of the palate.

Table 4

Partial Correlation Coefficients for Alveolar Arch Dimensions and Molar Occlusion

Standardized variables are Age, Sex, History of Orthodontic Treatment or Extractions, and other occlusal anomalies

Only Significant Coefficients are Presented

Alveolar Arch Dimension	Distal Molar Occlusion	Mesial Molar Occlusion
Maxillary Width Between—		
First Molars	−0.34■	
Second Bicuspids	−0.33■	
Cuspids	−0.27■	
Mandibular Width Between—		
Second Bicuspids		−0.17•
Mandibular Depth at—		
Second Bicuspids	+0.21■	−0.17•
First Bicuspids	+0.20■	

• $p<.05$ ■ $p<.001$

Table 5

Partial Correlation Coefficients for Alveolar Arch Dimensions and Incisor Occlusion

Standardized variables are shown in Table 4

Alveolar Arch Dimension	Overjet	Overbite
Mandibular Width Between—		
Second Bicuspids		+0.27■
First Bicuspids	−0.26■	
Cuspids		+0.31■
Palatal Height at—		
First Molars		−0.23■
Cuspids	+0.21■	−0.20■
Mandibular Width Between—		
First Bicuspids	−0.21■	
Mandibular depth at—		
Second Bicuspids	−0.17•	

• $p<.05$ ■ $p<.001$

In the case of "scissors" bite, the width of the maxillary arch between the second bicuspids and palatal height at the level of the first bicuspids was only slightly larger.

— Discussion —

Within this sample, both dental occlusion and alveolar arch dimensions varied widely, offering a good opportunity to study the associations between these characteristics.

The subjects were not evenly distributed in age or sex. These factors also affected the proportions of subjects with a history of previous orthodontic treatment and extraction of permanent teeth. Among subjects who had orthodontic treatment, the proportion of those with occlusal anomalies was slightly greater than in those with no such treatment. Extraction of permanent teeth was slightly related to the length of the alveolar arch at different levels.

Age, sex, history of orthodontic treatment and/or extraction of permanent teeth were confounding factors in the analyses of relationships between alveolar arch dimensions and occlusal anomalies. Because statistically significant correlations were found among different occlusal anomalies, other occlusal anomalies were also standardized when correlations between arch dimension and each occlusal anomaly were calculated.

When the effect of each dimension was analyzed, other dimensions were not standardized; therefore the size of the alveolar arch could be studied in relation to different types of occlusal anomalies, and the characteristics of occlusal traits and possible etiologic factors of malocclusions could be estimated.

In this study, correlations between dimensions of the maxillary alveolar arch

Table 6

Partial Correlation Coefficients for Alveolar Arch Dimensions and Transverse Occlusal Anomalies

Standardized variables are shown in Table 4

Alveolar Arch Dimension	Crossbite	Scissors bite
Maxillary Width Between—		
First Molars	−0.36▪	
Second Bicuspids	−0.42▪	+0.20▪
First Bicuspids	−0.33▪	
Cuspids	−0.34▪	
Palatal Height at—		
First Molars	+0.28▪	
Second Bicuspids	+0.16▪	
First Bicuspids		+0.17•
Mandibular Width Between—		
First Molars	+0.29▪	
Second Bicuspids	+0.31▪	
First Bicuspids	+0.21▪	

• $p < .05$ ▪ $p < .001$

and dimensions of the mandibular arch were lower than those reported previously by KNOTT (1961), and lower than correlation coefficients for widths of the dental arches but higher than for corresponding widths at the apical bases of the jaws described by SLAGSVOLD (1971).

SMYTH AND YOUNG (1932) and LAVELLE (1976) reported considerably higher values for partial correlation coefficients for the widths of the maxillary and mandibular dental arches.

Results from the different studies are not fully comparable because different points have been used for measurement. The correlation between maxillary and mandibular widths seems to be lowest for basal parts, higher between alveolar arches, and even higher for the dental arches.

Width of the dental arch has been reported to correlate positively with basal width of the jaw and also with that of the opposite jaw (SOLOW, 1966; SLAGSVOLD, 1971). The highest correlations observed in this study were in the region of the first permanent molars, 25% of the variation being related to dimensions of the opposite jaw. These findings support the hypothesis of the importance of first molars in dental occlusion.

For each dimension the correlations between different segments were high, especially for width and depth of the maxillary alveolar arch and for all dimensions in posterior segments, indicating that these dimensions may be determined largely by the same factors.

In the determination of arch dimensions, especially arch width, genetic factors have been found to play an important role (BERGFORS, 1936; RIQUELME AND GREEN, 1970; WOOD, 1971; CORRUCCINI AND POTTER, 1980; HARRIS AND SMITH, 1980). Environmental factors can also contribute to dimensional variation.

Functional factors – muscle pattern and occlusal forces – also differ in the anterior and posterior parts of the oral cavity, as well as laterally and vertically. The results of this study indicate that height of the palate and all dimensions in the cuspid region, and to a lesser extent in the bicuspid region, are influenced more by environmental or different genetic factors than are widths and lengths of alveolar arches.

In this sample, distal molar occlusion was related to extreme maxillary overjet, deep bite and scissors bite, all anomalies that often reflect a condition where the maxilla is excessively large in relation to the mandible.

Values for partial correlation coefficients between alveolar arch dimensions and distal molar occlusion showed a narrow maxilla located too far forward from the mandible, and a compensatory long mandibular arch in the bicuspid region. On the other hand, mesial molar occlusion was often combined with negative overjet, incisor openbite and crossbite, indicating that the maxilla was undersize compared to the mandible.

The partial correlation coefficients between different dimensions and mesial molar occlusion indicated only slight "compensatory" differences in the mandibular arch but no deviations in maxillary dimensions. Despite the rather high proportion of subjects with mesial molar occlusion, no severe progenias were found in this sample. In this study, distal and mesial molar occlusion were not associated with differences in alveolar arch dimensions, other than slight compensatory differences.

Negative overjet was associated with incisor openbite, and both these anomalies were associated with lateral crossbite. Combinations of these traits could be related to the maxilla being too small sagittally, vertically, and transversely. However, these results indicate that differences in alveolar arch dimensions are small and restricted mainly to the anterior parts of the arches.

With larger overjet, not only were alveolar arch widths and mandibular arch length larger, but palatal height, which represents basal parts of the maxilla better than the other dimensions, was also larger. With larger overbite, a tendency toward a broad but shallow maxilla was seen in the cuspid region and also in the posterior part of the maxilla.

In subjects with anterior occlusal anomalies almost all dimensions in the anterior segments of the maxilla appeared to be affected.

In cases of "scissors bite", which usually involved only a few teeth, hardly any differences in alveolar arch dimensions were found.

Among the different types of occlusal anomalies, crossbite was most clearly associated with differences in alveolar arch dimensions in both maxilla and mandible. Whether the differences are owing to dentoalveolar adaptations or to disproportions of skeletal dimensions could be determined only with the aid of anthropometric and cephalometric measurements not included in this study.

Genetic factors play a rather important role in determining width of the alveolar arches, so the rather high proportion of young Finnish adults with crossbite could be owing more to genetic factors than to environmental factors, which are often considered to be major causes of lateral crossbite.

Among cultures in transition from primitive to western culture, changes in the malocclusion pattern during one generation (Wood, 1971) are too rapid to be associated with genetic selection, raising the question of the importance of the physical consistency of the diet for transverse and sagittal occlusal development.

— Conclusions —

Only at the level of the first molars do width and depth of the alveolar arches seem to be to some extent related to the corresponding dimension in the opposite jaw. This supports the relative importance of first permanent molars in dental occlusion.

In subjects with distal molar occlusion, "compensatory" differences in alveolar arches tend to occur transversely in the maxilla and sagittally in the mandible. Dental relationships often disguise the degree of skeletal disproportion. In mild cases of mesial occlusion, compensatory changes are weak and are apparent only in the mandibular arch.

With large overjet, the tendency is toward a narrow, high palate and a narrow and short mandibular arch in the anterior segments. Among subjects with incisor deep bite, the palate seems to be somewhat broadened and flattened.

In this sample, "scissors bite" was not associated with alveolar arch dimensions, the effect being restricted to a few teeth. Crossbite, however, affected the width of both maxillary and mandibular arches and also the height of the palate.

The role of genetic factors in the etiology of crossbite may have been underestimated, even though environmental factors contribute considerably to development of the anomaly.

Altogether, occlusal anomalies were only slightly associated with differences in dimensions of the alveolar arches, some of which compensate for skeletal disproportions.

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