Alveolar Arch Dimensions, Orthodontic Treatment and Absence of Permanent Teeth Among Finnish Students

An Epidemiologic Study

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Statistical comparison of arch width, length and palatal height with age, sex, orthodontic treatment and extractions finds little correlation except a tendency for larger dimensions in males, especially in palatal width, and differences related to postextraction drift.

KEY WORDS: • ARCH DIMENSIONS • EXTRACTION • ORTHODONTIC TREATMENT •

The growth pattern of the palate and differences in dental arch dimensions during development of the dentition are well known but the reports on differences in these dimensions with advancing age during adulthood are not only scarce (SILLMAN 1964, BJÖRK AND SKIELLER 1974, SMITH AND BAILIT 1977), but the results are somewhat conflicting. Various sex-related differences in size and shape of the dental arches have been reported.

In studies of alveolar or dental arch dimensions, subjects with a history of orthodontic treatment or extraction of permanent teeth have usually been excluded, instead of investigating the possible relationships of these treatments on those dimensions.

The aim of this study is to evaluate mandibular and maxillary alveolar arch dimensions and palatal height in a group of young Finnish adults. Associations among these dimensions and age, sex, history of orthodontic treatment and extraction of permanent teeth are also evaluated.

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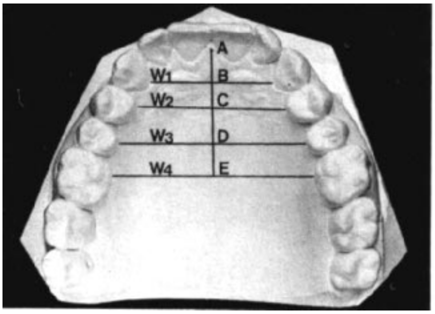


Fig. 1 Measurements of Width and Depth of Alveolar Arch

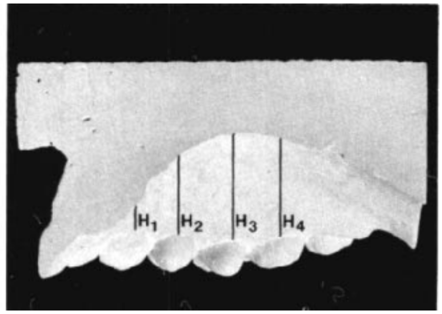


Fig. 2 Measurements of Palatal Height

— Materials and Methods —

The study sample was selected from 451 undergraduate students at Jyvaskyla University in middle Finland. A description of this sample has been published earlier (Laine and Hausen 1982). Subjects with extensive restorations, marked crowding or extraction of adjacent teeth in lateral segments were excluded. The final sample included 251 subjects.

Mean age of the subjects was 23.4 years, with the males averaging one year older than the females. The male:female ratio was <1:2.5. Eleven percent of the subjects had previous orthodontic treatment, mostly with removable appliances, and permanent teeth other than second or third molars, usually one or two teeth, had been extracted in 39% of the subjects. A more detailed description of the sample has been published (Laine and Hausen, 1982).

Hard stone casts were used for measuring dimensions of maxillary and mandibular alveolar arches and height of the palate.

Widths of the maxillary alveolar arch were measured between the most prominent palatal points of maxillary or mandibular cuspids, bicuspids, and first molars at the junction of the tooth and gingival margin (Fig.1).

Height of the palate was measured to the midline of the palatal vault from the level of the palatal width measurements between cuspids, bicuspids and first molars (Fig. 2).

All measurements were rounded to the nearest 0.5mm.

Horizontal depth values of the maxillary alveolar arch were measured along the midline of the palate from the central incisors to the four palatal width levels (Fig. 1). The anterior landmark was selected as suggested by Brown and Daugaard-Jensen (1951) at the point of intersection of the line connecting the most lingual aspects of the central incisors at their mesial ridges and the sagittal line. A rigid transparent plastic ruler was used as an aid, its edge connecting the points marking the cuspid, bicuspid or first permanent molar widths. The lengths between the anterior landmark and each dental arch width level were measured to the nearest 0.5mm with sharp-pointed vernier calipers.

Widths and lengths of the mandibular alveolar arch were measured similarly.

To calculate intraexaminer consistency, 40 randomly selected cases were measured before and after a one-week interval. Measurements ranged from −1.8% to +2.4%, with correlation coefficients from 0.87 to 0.99, indicating high intraexaminer consistency.

A structured questionnaire was used to obtain information about age and history of orthodontic appliance therapy. Type of appliances and duration of treatment were not recorded. Until recent years, mostly removable (non-functional) appliances were used in Finland.

Loss of permanent teeth was recorded from a clinical dental examination, with all examinations made by the same examiner. Since no radiographs were taken, all teeth not visible (except second and third molars) were recorded as extracted.

Multiple linear regression functions were fitted to analyze the combined relationships of age, sex, orthodontic treatment, and number of extractions of first permanent molars and teeth anterior to first molars with all dimensions. Because most of the values varied with sex and treatment histories, the mean values were calculated separately for male and female subjects with no treatment and for those with orthodontic treatment or extraction of permanent teeth. Two-way analyses of variance were applied for statistical evaluation of the differences among the groups.

In addition to the absolute alveolar arch dimensions, a relative value for each measurement was calculated as follows —

$$RW_i = 100\,W_i/\Sigma W_i \quad (i=1,2,3,4)$$
$$RL_i = 100L_i/L_{M1} \quad (i=1,2,3,)$$
$$RH_i = 100H_i/\Sigma H_i \quad (i=1,2,3,4)$$

where —

RW_i = relative arch width
RL_i = relative arch depth
RH_i = relative palate height
W_i = arch width at level i
L_i = arch depth at level i
H_i = palate height at level i
i = 1, cuspid level
i = 2, first bicuspid level
i = 3, second bicuspid level
i = 4, first permanent molar level
L_{M1} = arch depth to first molars

Multiple regression analyses were used to evaluate associations between relative values of alveolar arch dimensions and palatal height and the five independent variables of age, sex, and history of orthodontic treatment, extraction of permanent teeth anterior to the first molars, or extraction of first molars.

Because the only significant associations found by these analyses were those between extraction of permanent teeth anterior to the first molars and the relative depth of dental arches, only the differences in means between the different extraction groups are presented. Analyses of variance were used to evaluate the differences between extraction groups.

Maxillary and mandibular alveolar arch shapes are illustrated by drawing the mean values of widths and depths of both arches for male and female subjects with previous treatment and with no treatment.

— Results —

The mean values of absolute width and depth of maxillary alveolar arches were greater for males than for females (Table 1), but the difference was significant only for palatal width.

Palatal width values tended to be smaller among subjects with histories of orthodontic treatment or extraction of permanent teeth. The difference was statistically significant in the posterior part of the palate. No consistent differences were found between maxillary alveolar arch depths of treated and untreated subjects (Table 1).

In the group with no previous treatment, the means of absolute width and depth of mandibular dental arch tended to be insignificantly greater for males than for females. In all cases the associations with both sex and treatments were nonsignificant (Table 2).

Palatal height values were greater for males than for females at the level of first permanent molars and possibly at the level of second bicuspids, but not at the level of first bicuspids and cuspids (Table 3). The association between sex and palatal height tended to weaken from the posterior part of the palate toward the premaxilla, while the associations with treatment seemed to be greatest toward the anterior part of the palate. Most differences, did not reach statistical significance.

In the maxilla the relative depth values of the alveolar arch were almost equal in subjects with no extractions and those who had lost one permanent tooth anterior to the first molars (Table 4). The difference with two extractions was considerable, with smaller relative depths at the levels of second and first bicuspids.

In the mandible, no mean differences were found between subjects with no extraction and those with one extraction (Table 5). With two extractions, the mean relative depth was greater at the level of first bicuspids and cuspids. The distribution of the subjects did not allow comparisons at the level of second bicuspids.

In the maxilla, the lingual surfaces of bicuspids and first permanent molars formed an increasing curve toward the posterior part of the dental arch (Fig. 3). The shape of this segment of the mandibular dental arch was nearly semicircular. No differences in average arch shape

Table 1

Mean Horizontal Dimenions of the Maxillary Arch
with No Treatment and with Orthodontic Treatment or Extractions

Mean in millimeters (Standard Deviation) — P values by two-way analysis of variance

	No Treatment		Orthodontics or Extraction		P value Effect of — Sex	Trt.
Width	♀	♂	♀	♂		
First Molars	34.1 (2.5)	36.5 (2.9)	33.0 (3.2)	33.9 (2.9)	<.001	<.001
Second Bicuspids	31.8 (2.6)	34.1 (3.8)	31.1 (3.7)	32.5 (2.9)	<.001	0.027
First Bicuspids	27.5 (2.2)	29.5 (2.4)	27.1 (2.6)	28.5 (2.6)	<.001	0.131
Cuspids	25.1 (1.9)	26.6 (1.8)	25.2 (2.0)	26.3 (2.0)	<.001	0.237
Depth						
First Molars	24.9 (1.9)	24.8 (2.1)	24.4 (2.1)	25.4 (2.4)	0.032	0.369
Second Bicuspids	17.7 (2.0)	17.9 (1.9)	17.1 (2.1)	17.9 (2.3)	0.117	0.145
First Bicuspids	11.2 (1.7)	11.3 (1.3)	10.9 (1.7)	11.4 (1.7)	0.364	0.395
Cuspids	5.8 (1.3)	6.0 (1.2)	5.7 (1.5)	6.2 (1.3)	0.057	0.918

were found between the sexes nor between the treated and untreated groups.

— Discussion —

The subjects were undergraduate students, mostly females who, on average, were younger than the males. In spite of many special characteristics of university students, there is no reason to believe that the relationships of age, sex, orthodontic treatment or extraction of permanent teeth on alveolar dimensions would be different among students compared to other population groups with the same age range.

As the distribution of age and sex were skewed, these factors were not included in the analyses of associations between the studied dimensions and orthodontic treatment and/or different types of extraction.

In previous studies, dental arch width between contralateral teeth has been measured in many different ways — between the most labial points (Knott, 1961), the most distal points (Koski, 1948; Sillman, 1964; Howell, 1981), the most palatal or lingual points (Brawley and Sedwick, 1939; Shapiro et al., 1963; Williams, 1964; Redman et al., 1966; Knott and Johnson, 1970; Riquelme and Green, 1970; Björk and Skieller, 1974), or a mean between the most labial and palatal mea-

Table 2

Mean Horizontal Dimenions of the Mandibular Arch
with No Treatment and with Orthodontic Treatment or Extractions

Mean in millimeters
(Standard Deviation)

P values by two-way
analysis of variance

	No Treatment		Orthodontics or Extraction		P value Effect of —	
					Sex	Trt.
Width	♀	♂	♀	♂		
First Molars	32.1 (2.2)	33.1 (2.5)	32.0 (3.1)	31.9 (3.8)	0.059	0.180
Second Bicuspids	29.5 (2.5)	29.9 (2.1)	29.6 (3.1)	29.4 (3.1)	0.661	0.783
First Bicuspids	25.9 (1.9)	26.5 (1.7)	25.9 (2.2)	26.3 (2.2)	0.093	0.688
Cuspids	19.3 (1.5)	19.3 (1.3)	19.3 (1.5)	19.0 (1.3)	0.645	0.521
Depth						
First Molars	20.4 (1.6)	20.8 (1.3)	20.2 (1.8)	20.5 (1.7)	0.186	0.225
Second Bicuspids	13.7 (1.7)	14.3 (1.1)	14.0 (1.7)	13.8 (1.6)	0.209	0.671
First Bicuspids	8.3 (1.3)	8.4 (1.0)	8.5 (1:4)	8.1 (1.3)	0.774	0.532
Cuspids	3.7 (1.3)	3.8 (1.2)	3.9 (1.3)	3.7 (1.4)	0.873	0.598

surements has been calculated (Olow, 1954).

Several different anterior and posterior landmarks have also been used in studies reporting dental or alveolar arch depth. The primary purpose for collecting the present data was to study associations between speech disorders and morphology of the dentition and the palate, where the area of the palate used during articulation of consonants is of great importance. This concern with inside arch space required using the most palatal points of cuspids, bicuspids and first molars. Tongue space is also of concern to orthodontists, so this method which eliminates the relationship of buccolingual tooth dimensions is also appropriate for these purposes.

The recordings were made at the junction of the tooth and the gingival margin, in order to get dimensions representing the alveolar as well as dental arch. For this reason, subjects with remarkable local deviations in the dental arches, such as marked crowding or several extractions of adjacent teeth, were excluded from the study sample. Exclusion of these subjects decreased the variation in number of extractions and thus possibly decreased the statistical significance of extraction in the multiple regression functions.

The anterior palatal landmark (Brown and Daugaard-Jensen, 1951) coincided with the incisive papilla or was situated labially to it. In some cases an enlarged incisive papilla made measuring difficult, but the high intraexaminer consistency indicates that using this point did not cause significant errors in measurement. The incisive papilla was selected as a measuring point because it is an important area during articulation of consonants, and this anatomic area is thought to be less variable than the interincisal point (Riquelme and Green, 1970).

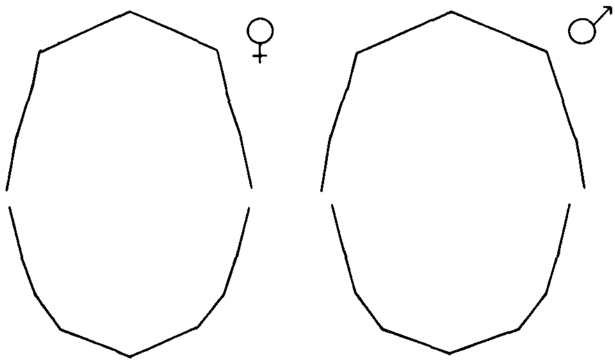
The precision of the vernier calipers used in measuring width and depth of dental arches was 0.01MM, but measurements were rounded to the nearest 0.5MM. Compression of the mucous

Table 3

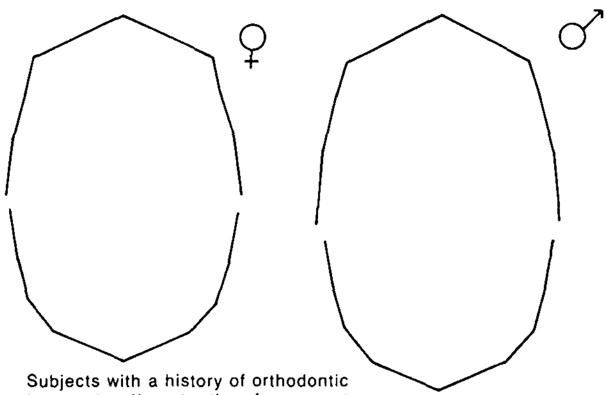
Palatal Height
in 251 Finnish Students
with No Treatment and with Orthodontic Treatment or Extractions

Mean in millimeters (Standard Deviation) — P values by two-way analysis of variance

Heighth at –	No Treatment		Orthodontics or Extraction		P value Effect of —	
	♀	♂	♀	♂	Sex	Trt.
First Molars	15.5 (2.2)	20.8 (2.3)	15.5 (2.3)	16.4 (2.1)	0.002	0.719
Second Bicuspids	13.7 (2.3)	14.7 (2.2)	14.1 (2.3)	14.2 (2.1)	0.189	0.780
First Bicuspids	8.9 (2.3)	9.0 (2.6)	8.6 (2.1)	8.2 (1.7)	0.520	0.164
Cuspids	2.7 (1.3)	2.8 (1.2)	2.5 (1.3)	2.3 (1.2)	0.603	0.073



Subjects with no history of orthodontic treatment or extraction of permanent teeth



Subjects with a history of orthodontic treatment and/or extraction of permanent teeth.

Fig. 3 **Average Shapes of Maxillary and Mandibular Alveolar Arches, based on the measurements shown in Figures 1 and 2**

Table 4

Relative Maxillary Arch Depth

Level of Measurement	No Extractions		One Extraction		Two Extractions		p
	N	Mean	N	Mean	N	Mean	
Second Bicuspids	214	71±4	14	69±4	4	61±9	0.0001
First Bicuspids	214	45±4	14	44±5	2	32±6	0.0003
Cuspids	218	23±5	16	24±5	3	30±8	0.0714

membrane and volume changes in materials used in the preparation of stone casts do not warrant a greater precision.

No age differences were found in mean values of width and depth of alveolar arches, or in values of palatal height. The results in palatal height are in accordance with studies showing an increase of palatal height up to 18 years with no change after that (BRAWLEY AND SEDWICK 1939, REDMAN ET AL., 1966, KNOTT AND JOHNSON 1970) and also with studies reporting no association between palatal height and age among adults (SCHERRA, 1969; VIDIC, 1971; KLAMI AND HOROWITZ, 1979).

Intermolar dental arch width has been reported to increase up to 11-15 years (OLOW, 1954; KNOTT, 1961; REDMAN ET AL., 1966), and according to findings of SMITH AND BAILIT (1977), even up to 30 years, while BJÖRK AND SKIELLER (1974) found mainly a pubertal increase followed by a decrease during the postpubertal period up to the age of 20 years.

Growth between the maxillary cuspids has been reported to stop as early as age 7 (OLOW, 1954; BJÖRK AND SKIELLER, 1974). After that age the intercuspid width has been reported to narrow by BJÖRK AND SKIELLER (1974) and SMITH AND BAILIT (1977). MOORREES AND REED (1965) found a second period of increase in the intercuspid distance measuring from the cusp tip with the emergence of the permanent cuspids in the maxilla, but not in the mandibular dentition.

Shortening in dental arch length after 10-12 years of age has been found up to 25 years by SILLMAN (1964), and up to the seventies by SMITH AND BAILIT (1977).

When considering the results of the studies mentioned above, and studies reporting enlargement of other cranial dimensions until 30 years of age (KENDRICK AND RISINGER, 1967; ISRAEL, 1973), we expected to find some associations between age and alveolar arch dimensions. One explanation for our negative findings may be that the yearly differences in dental arch and palatal dimensions among young adults are so small and individual differences so large that within the narrow age range of the students it could not be detected by such a small cross-sectional study.

In our study, males tended to have larger alveolar arch dimensions than females. The differences were highly significant for maxillary widths, which is in accordance with KOSKI (1948), KNOTT (1961), REDMAN ET AL., (1966), AND SMITH AND BAILIT (1977).

Among the other dimensions, statistically significant differences between

Table 5

Relative Mandibular Arch Depth

Level of Measurement	No Extractions		One Extraction		Two Extractions		p
	N	Mean	N	Mean	N	Mean	
Second Bicuspids	190	67±5	13	68±4	1	65±0	0.7023
First Bicuspids	189	40±5	15	40±5	3	50±4	0.0039
Cuspids	190	18±6	16	18±6	4	26±5	0.0271

males and females were found only at the level of maxillary first permanent molars. The observed greater dental arch depth among males compared to females is in accordance with the results of earlier studies (BRAWLEY AND SEDWICK, 1939; KOSKI, 1948; SMITH AND BAILIT, 1977).

In our study, males tended to have higher palates at the level of first molars, while no differences in palatal height between the sexes have been reported previously (BRAWLEY AND SEDWICK, 1939; VIDIC, 1971; KLAMI AND HOROWITZ, 1979). The observed differences between males and females reflect the sexual dimorphism in body size, but the wide individual differences in skull dimensions may obscure other differences.

No differences in the shapes of maxillary and mandibular alveolar arches could be found when comparing males and females or subjects who had orthodontic treatment or extraction of permanent teeth with those who had not had such treatment. This finding indicates that even though the variation in shape of alveolar arches is very wide, the distribution of different shapes of the arches tends to be the same in different groups.

On the other hand, the illustrated "mean shape of alveolar arch" represents an arch form that does not match any of the studied subjects. The shapes of both maxillary and mandibular arches illustrated in this study resemble dental arch shapes described by HERREN (1971, 1976) in spite of differences in methods. Herren measured dimensions between mesiodistal contact points of the teeth and included only subjects with ideal occlusion. The shape of mandibular arch measured on lingual surfaces of the teeth was more evenly curved than that of maxilla.

As the shapes of dental arches are determined by both genetic and environmental factors, the observed difference between the shapes of maxilla and mandible could result from the different effects of the tongue upon the arches. Among functional factors determining the final tooth position (PROFFIT 1978, MOSS 1980), the postural position and muscle forces of the tongue seem to play a more important role in moulding the shape of the mandibular arch.

— Summary and Conclusions —

This study of palatal height and the width and depth of maxillary and mandibular alveolar arches among Finnish students evaluates associations between those dimensions and age, sex, histories of orthodontic treatment and extraction of permanent teeth.

Alveolar arch and palatal dimensions did not seem to differ from those of other Caucasoid population groups with the same age range. Age was not correlated with the values of the studied dimensions. Males tended to have larger dimensions than females, especially in maxillary alveolar arch width.

No systematic differences could be found between the subjects with previous orthodontic treatment and subjects with no such treatment. Extraction of permanent teeth anterior to the first molars affected the depths of both maxillary and mandibular arches as measured to dental landmarks.

The migration tendency of the teeth remaining after extraction of permanent teeth anterior to the first molars seemed to be somewhat different in maxilla and mandible, with more migration after extraction in the maxilla.

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