Space Anomalies, Missing Permanent Teeth and Orthodontic Treatment

Tellervo Laine
Hannu Hausen

Statistical association of crowding and spacing with age, sex, orthodontic treatment and extractions finds a tendency for more maxillary posterior spacing in males and more lower anterior spacing in females. Extractions were also associated with spacing. No association was found between spacing and orthodontic treatment.

KEY WORDS: • AGE • CROWDING • EXTRACTION • ORTHODONTIC TREATMENT • SEX • SPACING •

In Finland, as well as in other Scandinavian countries, the incidence of space anomalies in children and adolescents is well known, but little information is available about older groups in the population.

Changes in space conditions of males and females during development of the dentition have been documented by HELM (1970), MYLLÄRNIEMI (1970), STRATFORD (1973), THILANDER AND MYRBERG (1973), AND MAGNUSSON (1977). Less information is available about the possible relationships of age and sex with the occurrence of spacing and crowding in adults (LOMBARDI AND BAILIT, 1972; SMITH AND BAILIT, 1977).

In countries with high standards of dental care, orthodontic treatment is becoming more frequent, and extraction of permanent teeth due to caries is becoming less frequent. Possible differences in space conditions arising from these trends are not known.

The aims of this study were to report frequencies of spacing and crowding in Finnish students and determine any differences in relationships between the occurrence of space anomalies and age, sex, history of orthodontic treatment, and loss of permanent teeth.

— Materials and Methods —

The study sample consisted of 451 undergraduate students at Jyvaskyla University in middle Finland. A description of this sample has been published earlier (LAINE AND HAUSEN 1982).

We used a structured questionnaire to obtain information about previous orthodontic treatment with appliances. Until recently, mostly removable appliances were used in Finland. Extraction of permanent teeth other than second or third molars was recorded in clinical dental examinations made by the same examiner. Since no x-rays were taken, all teeth not visible were considered to have been extracted.

During the dental examination a mouth mirror and periodontal probe (scale in MM) were used to measure the degrees of crowding and spacing. Space conditions were diagnosed and recorded separately for anterior and lateral segments of the maxillary and mandibular dental arches.

The most distal point of clinically observable crown of the cuspid was considered as the boundary between the anterior and lateral segments.

Data for the left and right lateral segments of each jaw were combined. Overlapping and spacing were summed separately for each segment. A segment was considered to be crowded or spaced when the total exceeded 2MM.

Space conditions were first calculated for the entire sample. Subjects were then divided into two groups, those with histories of orthodontic treatment or extraction of permanent teeth, and those without either treatment. Frequencies of space anomalies and the mean values for spacing were recorded separately for these two groups. Chi-square test and Student's t-test were applied for statistical evaluation of the differences between groups.

Multiple linear regression functions were fitted to analyze the combined relationships of age, sex, previous orthodontic treatment, extraction of permanent teeth anterior to the first molars, and extraction of first permanent molars to spacing (MM). First, the complete set of the five independent variables were included in the functions. Thereafter, variables that had no statistically significant relationship with spacing in the studied segment were excluded one by one from the function, starting from the weakest variable.

The combined relationships of the five factors to frequencies of crowding were analyzed using multiple logistic regression functions (WALKER AND DUNCAN, 1967). Before fitting these functions we dichotomized all the variables. According to these analyses, first permanent molar extraction was the only factor associated with crowding in any segment. Therefore, the proportions of subjects with crowding among persons with and without such extraction were given, and the effects of other variables were excluded. Chi-square statistics were used to evaluate the differences.

— Results —

Spacing in excess of 2MM in maxilla, mandible or both was found in 38% of the subjects. Crowding in excess of 2MM in maxilla, mandible or both was found in 34%. Both crowding and spacing were found in 5%, and 33% had neither.

Table 1 shows the frequencies of spacing and crowding in different segments of maxilla and mandible. When all segments were considered, spacing was about equally common in both jaws, while the proportions of subjects with spacing in different segments varied considerably. Crowding was more frequent in the mandible than in the maxilla, and also in anterior segments than in lateral segments.

The proportion of subjects with spacing in all segments of the mandible and at least the lateral segments of the maxilla was clearly greater among those with histories of orthodontic treatment or extraction of permanent teeth. For crowding, the reverse was true in all segments of the mandible and marginally so in the maxilla (Table 1).

The mean sums of spaces in different segments of both maxilla and mandible were smaller among untreated subjects (Table 2). In lateral segments the differences were greater than anteriorly.

In further analyses, the combined relationships of the five factors with spacing in anterior and lateral segments of maxilla and mandible were evaluated with multiple linear regression functions.

In the maxillary anterior segment, the only factor related to the space value was extraction of permanent teeth anterior to the first molars ($P < 0.001$). Therefore, only mean sums of spaces according to number of extractions are given. Among

subjects without such extractions the mean sum of spaces was 0.6MM (S.E. 0.1); in subjects with one extraction the value was 1.0MM(0.3), with two or more extractions 2.4MM(0.9).

Sex and both patterns of extraction were significantly related to lateral spacing in the maxilla (Table 3). According to the fitted regression function, mean lateral spacing in the maxilla with the same extraction patterns was 0.7MM larger in males than in females.

With extraction of one permanent tooth anterior to the first molar, mean space was 1.7MM larger, and with first molar extraction it was 3.5MM larger. Relative magnitudes of regression coefficients for sex and extraction were almost the same.

In the anterior segment of the mandible, mean spacing in males was smaller

Table 1

Incidence of Subjects with Space Anomalies

	Total N=451	No Treatment N=250	Orthodontics or Extraction N=201	X_1^2
Maxillary Spacing	25%	14%	40%	40.09▪
Anterior	15%	13%	18%	2.70
Lateral	16%	4%	31%	60.38▪
Mandibular Spacing	24%	3%	53%	143.15▪
Anterior	6%	3%	9%	9.08•
Lateral	22%	1%	49%	144.86▪
Maxillary Crowding	7%	9%	5%	2.93
Anterior	7%	8%	5%	2.04
Lateral	1%	2%	1%	1.24
Mandibular Crowding	32%	40%	21%	19.58▪
Anterior	31%	39%	21%	17.44▪
Lateral	8%	10%	5%	4.46•

• $p<.05$ • $p<.01$ ▪ $p<.001$

Table 2

Mean Space Values (mm) by Segments

	No Treatment Mean	SE	Orthodontics or Extraction Mean	SE	p
Maxillary Anterior	0.6	0.1	1.0	0.2	0.042
Maxillary Lateral	0.2	0.1	1.9	0.3	<0.001
Mandibular Anterior	0.1	0.1	0.4	0.1	0.007
Mandibular Lateral	0.1	0.0	4.6	0.5	<0.001

two-tailed t statistics, separate variance estimates

than in females (Table 4). With extraction of a lower first permanent molar the mean was slightly greater. The other factors appeared to be unrelated to anterior spacing in the mandible. The relationship of extraction of a first permanent molar to mandibular spacing was 2.5 times stronger than that of sex.

Extraction of any buccal teeth clearly increased spacing in lateral segments of the mandible (Table 5), extraction of a first molar twice as much as extraction of a bicuspid. The other factors were unrelated to mandibular buccal spacing.

Multiple logistic regression functions of the combined associations between the variables and the presence of crowding in anterior and lateral segments of maxilla and mandible were also determined. Because first permanent molar extraction was the only factor associated with crowding by this criterion, these associations are presented in Table 6 as differences in incidence. Extraction of one or both first permanent molars appeared to eliminate crowding in excess of 2MM in all maxillary segments and in lateral mandibular segments. Anterior crowding in the mandible was also remarkably less common among subjects with lower first molars extracted.

Table 3

Selected Variables vs. Lateral Maxillary Spacing

by a multiple linear regression function

	Regression Coefficient	SE of Coefficient	Standardized Coefficient	F value
Sex (♀ = 0 ♂ = 1)	0.71	0.11	0.24	8.80•
Extraction(s) Mesial to M1	1.65	0.29	0.21	59.55■
1st Molar Extraction(s)	3.50	0.54	0.24	205.95■
Constant term	−0.11			

Table 4

Selected variables vs. Anterior Mandibular Spacing

by a multiple linear regression function

	Regression Coefficient	SE of Coefficient	Standardized Coefficient	F value
Sex (♀ = 0 ♂ = 1)	−0.24	0.11	−0.10	4.61•
1st Molar Extraction(s)	+0.42	0.08	+0.25	31.10■
Constant term	0.17			

— Discussion —

The subjects in this study were undergraduate students. The majority of Finnish students are females who tend to be younger than the male students. For this reason and possibly other special characteristics of university students, the frequencies given for space anomalies cannot be projected to the entire population. There is, however, no reason to believe that the observed relationships of different factors to space conditions would have been different in other Finnish population groups of the same age range.

In epidemiologic studies on space anomalies, subjects with histories of orthodontic treatment or extraction of permanent teeth are often excluded (KEENE, 1963; LAVELLE AND FOSTER, 1969; HELM, 1970; LAVELLE, 1970; MAGNUSSON, 1977). In our study about half of the subjects reported a history of one of these treatments, and considerable differences were found between space conditions in the treated and untreated students. Therefore, the frequencies are presented separately for each group.

Two different types of multivariate techniques were applied to evaluate the relative importance of the studied factors on space anomalies. For spacing that was recorded on a continuous scale, multiple linear regression functions were constructed using numbers of the two categories of extraction.

Because the crowding values were categorized during the recording proce-

Table 5

Selected Variables vs. Lateral Mandibular Spacing
by a multiple linear regression function

	Regression Coefficient	SE of Coefficient	Standardized Coefficient	F value
Extractions Mesial to M1	3.72	0.32	0.34	136.92*
1st Molar Extraction(s)	5.22	0.22	0.68	552.32*
Constant term	−1.10			

Table 6

Incidence of Subjects with Crowding

	No 1st Molar Extraction N=304	1st Molar Extraction(s) N=121	X_1^2
Anterior Maxillary	8%	–0–	5.01•
Lateral Maxillary	1%	–0–	0.76
Anterior Mandibular	38%	7%	36.00*
Lateral Mandibular	10%	–0–	11.43*

dure, logistic regression functions were fitted using all variables as dichotomous.

In comparing our results with earlier findings, we considered only the subjects without histories of orthodontic treatment or extraction of permanent teeth, selecting studies using the same criteria (BJÖRK ET AL., 1964) on Caucasoids with permanent dentition (HELM, 1970; STRATFORD, 1973; LAVELLE, 1976; MAGNUSSON, 1977; INGERVALL ET AL., 1978; HELM AND PRYDSÖ, 1979).

In this study, maxillary spacing was more common in the anterior segment than in lateral segments. In the mandible, no clear differences were found between the segments. The observed proportions agreed well with those reported earlier. Spacing values for the mandible and the anterior segment of the maxilla were near the middle of the wide range of values reported by others. Frequency of lateral spacing in the maxilla was about equal in all studies.

In our study and in the other studies, crowding was more prevalent in the mandible than in the maxilla, and in both jaws it was more common in the anterior than in lateral segments. Nevertheless, reported crowding values for different segments vary from study to study. In our study and in those of STRATFORD (1973) AND INGERVALL ET AL., (1978), about one-tenth of the subjects had anterior crowding in the maxilla, while others have reported higher frequencies. We found less lateral crowding both in the maxilla and the mandible, and more anterior crowding in the mandible, than has been reported previously.

No association was found between space anomalies and age in this study, possibly owing to the age structure of our sample. Most were 20 to 30 years old, a period when dentition changes are small, resulting mainly from minor growth of the mandible (BJÖRK, 1963; KENDRICK AND RISINGER, 1967). Different associations between age and space conditions have been found in other studies, but the age structure of those samples was different — either adolescents below 20 years (BROWN AND DAUGAARD-JENSEN, 1951; MYLLÄRNIEMI, 1970; CHUNG ET AL., 1971), or groups with a much wider age range (LOMBARDI AND BAILIT, 1972; SMITH AND BAILIT, 1977).

In the present study, males had more lateral spacing in the maxilla and less anterior spacing in the mandible than females. In other studies spacing in either arch, especially in anterior segments, has been reported to be more common in males than in females (HELM, 1970; CHUNG ET AL., 1971; MAGNUSSON, 1977). The incidence of crowding in the maxilla has been found to be higher among females (HELM, 1970; MYLLÄRNIEMI, 1970; WIEMANN ET AL., 1977), as has anterior mandibular crowding (LAVELLE AND FOSTER, 1969).

Orthodontic appliance therapy was not associated with space anomalies in this study. RICHTER (1978) found a higher frequency of malocclusions, including space anomalies, among subjects with histories of prior orthodontic treatment when he compared them with subjects who had not had such treatment. However, EISMANN (1980) reported that orthodontic therapy with removable appliances was effective in diminishing the frequency of crowding, especially in the upper jaw, but found that such therapy did not reduce the incidence of spacing.

Our findings concerning spacing are in accordance with those of Eismann. Possible success of orthodontic treatment of crowding may be partly concealed by the sensitivity of our criteria, absence of pretreatment data, and by changes in space conditions after orthodontic therapy. EISMANN (1980) reported increasing crowding in the maxilla and even more in the mandible during the post-retention period, regarding this as a consequence of developmental changes.

THILANDER ET AL. (1963) found that excess space remaining after extraction of first molars was distributed as diastemas along lateral segments and to some extent also in anterior segments of both arches.

In our sample anterior spacing was found in the mandible but not in the maxilla. The effect of extraction of upper first molars appeared as diastemas only between the upper cuspids and second permanent molars. The lack of anterior spaces could be owing to backward movement of incisors caused by lip function, a conclusion that agrees with SEIPEL (1946) AND THUNOLD (1970).

As expected, extraction of permanent teeth anterior to the first permanent molars was related to a higher incidence of spacing. In the maxilla, this was evident as spaces in all segments. In the mandible, however, extractions were significantly related to more spacing only in the lateral segments. The lack of a difference in spacing in the mandibular anterior segments where permanent teeth anterior to the first molars had been extracted is difficult to explain without more information about the chronological and dental age and dental relationships of each subject at the time of extraction.

Our results suggest that extraction of first permanent molars did eliminate some crowding, but significant anterior mandibular crowding remained in the group who had lost one or both mandibular first permanent molars. Similarly, extraction of permanent teeth anterior to the first molars relieved crowding, but the effect was small.

The difference between the effects of extraction of first permanent molars and teeth anterior to them on occurrence of crowding may be due to differences in the size of the teeth and in the extraction timing. We had no information about the time or reason for extraction, but in the case of crowding most were probably done during the mixed dentition period.

The strong effect of extraction of first permanent molars on anterior crowding in both jaws, especially in the maxilla, indicates a considerable tendency for the teeth to migrate. Migration of the teeth toward the site of extraction seems to be greater in the maxilla than in the mandible. Up to the third decennary, self-correction of extraction spaces and a tendency toward crowding as the dentition developed (BROWN AND DAUGAARD-JENSEN, 1951; MYLLARNIEMI, 1970) probably weakened the observed decreasing effect of both types of extraction on crowding values.

— Summary and Conclusions —

The frequency of space anomalies in Finnish students and associations with age, sex, history of orthodontic treatment, and extraction of permanent teeth are reported. Generally, the space conditions of these Finnish students seem to be similar to those reported by others from corresponding populations.

In these young adults, space anomalies were associated with sex but not with age. For males, spacing was more common in maxillary lateral segments and less common in the mandibular anterior segment than for females.

No clear differences in space conditions were found between subjects who reported previous orthodontic treatment and those with no such treatment. The seeming ineffectiveness of orthodontic treatment on space anomalies may partly be due to less effective treatments - mainly with removable appliances - and partly due to post-retention changes in dentition.

Spaces caused by extraction were distributed as diastemas along the whole dental arch, except that with extraction

of permanent teeth anterior to the lower first molars the effect was more local. Extraction of first permanent molars affected spacing and crowding in the upper jaw more than in the lower jaw, and reduced crowding more than extractions of more anterior teeth.

This study was supported by the Finnish Dental Society and the North Savo Fund of the Finnish Cultural Foundation.

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