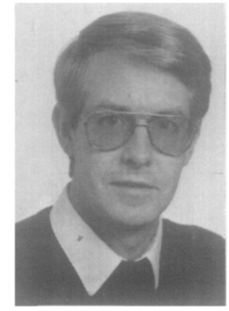
Ectopic eruption of the maxillary first permanent molar: Etiologic factors



Dr. Bjerklin

Krister Bjerklin, D.D.S., and Jüri Kurol, D.D.S.
Jönköping, Sweden

For clinical handling, it is important to determine whether any etiologic factors, alone or in combination, are of more importance than others in causing ectopic eruption of a maxillary first permanent molar. Etiologic factors involved in ectopic eruption of maxillary first permanent molars were investigated in 129 children with a mean age of 8.6 years. Ninety-two children (fifty-eight boys and thirty-four girls) had ectopic eruption and thirty-seven children served as controls and were matched by age and sex. Two types of ectopic eruption could be distinguished: a reversible type in which the permanent molar frees itself and an irreversible type in which the permanent molar remains in a locked position. Measurements were made on lateral head films, orthopantomograms, and dental casts. For 104 subjects all variables could be measured. Data was analyzed by discriminant analysis. Children with irreversible ectopic eruption had significantly larger permanent molars and a more pronounced mesial angle of eruption. A tendency toward a shorter maxilla was also found. No significant difference was found between sides with reversible ectopic eruption and sides with normal eruption. From the discriminant analysis between groups and all variables investigated, 90.7 percent of the cases could be correctly classified into groups. This study indicates that sufficient space may be gained for the premolars if the mesial tipping of the first molar is corrected, despite the tendency toward a shorter maxilla and larger than normal permanent molars.

Key words: Tooth eruption ectopic, molar, etiology, prediction, orthodontics

Ectopic eruption of the maxillary first permanent molar is a local eruption disturbance. The molar then comes into contact apical to the prominence of the distal surface of the second deciduous molar and causes an atypical resorption in this area. Two types of ectopic eruption (reversible and irreversible) can be distinguished, as reported by us in 1981[1] (Fig. 1). In the first type, called "jump cases" by Young,[2] the molar frees itself and erupts into the normal position in the dental arch. Reversible ectopic eruption thus means that the second deciduous molar remains mesial to the erupted maxillary first permanent molar, but with a more or less pronounced atypical resorption. In the irreversible type, called "hold cases" by Young,[2] the maxillary first permanent molar remains in contact with the distal part of the second deciduous molar in the cervical area and does not erupt into the normal position.

Over the years a number of prevalence studies of ectopic eruption of the maxillary first permanent molars have been reported in the dental literature. From these reports, it can be seen that the prevalence varies between 2 percent and 5.99 percent.[1–7]

A number of authors have discussed different theories concerning etiologic factors. One is that the morphology of the distal bullous contour of the maxillary second deciduous molars predisposes to locking of the permanent molar during its eruption.[7] Small arches, the path of eruption of the permanent molar, and early eruption of the maxillary first permanent molars are other factors that may cause ectopic eruption of the permanent molar, according to Chapman.[8] Cheyne and Wessels[4] thought that lack of bony growth in the tuberosity region could be of importance for molar eruption. Ectopic eruption of the first permanent molar can be a manifestation of arch length deficiency.[9–11] Other possible factors that have been mentioned in the literature are an excessive mesial direction of the eruption path of the first permanent molar[4, 8, 12–14] or greater than normal size of the first permanent molar.[3, 5, 10, 11, 14–16]

Pulver[5] examined lateral cephalograms and dental casts from forty-six children with ectopic eruption, 4 to 12 years of age. He suggested that a combination of factors contributed to ectopic eruption of the maxillary first permanent molar: (1) larger than normal maxillary deciduous and permanent teeth; (2) smaller than normal length of the maxilla; (3) posterior position of the maxilla in relation to the cranial base; (4) abnormal angulation of eruption of the permanent molar; and (5) delayed calcification of some affected first permanent molar.

From the Department of Orthodontics, The Institute for Postgraduate Dental Education.

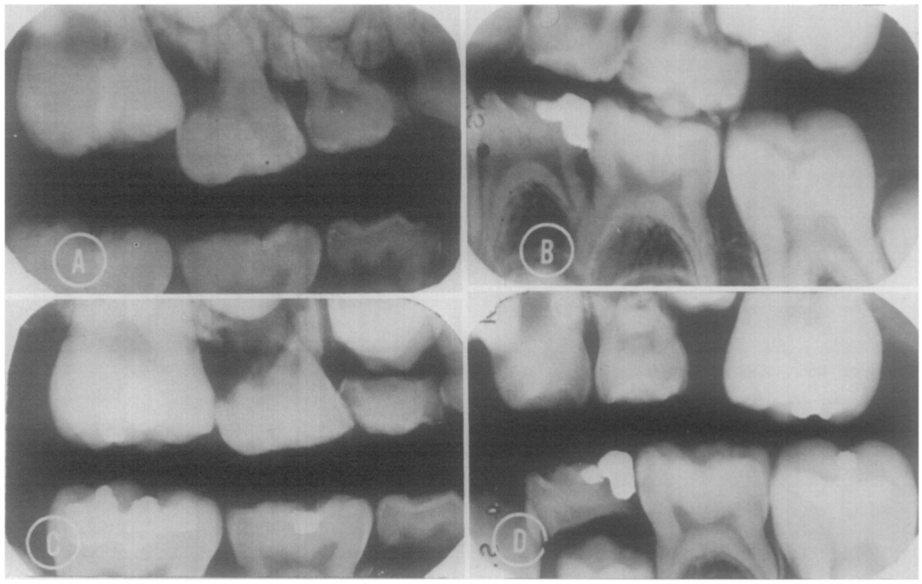


Fig. 1. Ectopic eruption of maxillary first permanent molars. **A,** Reversible type. **B,** Roentgenogram taken 1 year 1 month later with spontaneous self-correction. **C,** Irreversible type. **D,** Roentgenogram taken 1 year later with severe space loss following early loss of deciduous molar.

Ectopic eruption has a significant familial tendency.[17] Both recessive inheritance with reduced penetrance in girls and multifactorial inheritance are possible. When a child in a sibling complex has ectopic eruption of the first permanent molar, the probability of one of the other children showing the same eruption disturbance is greater than for a sibling complex in which no child has this type of eruption disturbance.

The purpose of this study was to determine whether any etiologic factors, alone or in combination, are of more importance than others in causing ectopic eruption of a maxillary first permanent molar and also to distinguish between variables which predispose to irreversible and reversible ectopic eruption.

MATERIAL AND METHODS

The study comprised 129 children, of whom 92 (58 boys and 34 girls) had ectopic eruption of at least one maxillary first permanent molar in the upper jaw. The mean age was 8 years 6 months, with a standard deviation of 0.8 and an age range of 6 years 1 month to 10 years 4 months.

Twenty-four of the children had bilateral irreversible ectopic eruption. Thirty-three children had irreversible ectopic eruption on one side and either reversible ectopic eruption or normal eruption on the other side. Bilateral reversible ectopic eruption occurred in 15 children. Twenty children had reversible ectopic eruption on one side and normal eruption of the molar on the other side (Table I). Thus, irreversible ectopic eruption occurred on 48 right sides and 33 left sides.

Among children with irreversible ectopic eruption, there were early-detected cases in which the resorbed second deciduous molar had not yet been extracted and the permanent molar remained in a locked position. This occurred bilaterally in 8 children, whereas 12 children had unilateral irreversible ectopic eruption in which the second deciduous molar had been extracted.

The control group consisted of 37 children with normal eruption. These children were matched for age and sex with the children who had irreversible ectopic eruption.

For measurements, panoramic radiographs (orthopantomograms), lateral head films taken in a cephalostat, and dental casts made of stone were used. All registrations and measurements were performed by us.

Measurements on lateral head films

The reference points and lines shown in Fig. 2 are those used by Björk[18] and Solow,[19] with the following additions:

A-B on OL—The distance between the perpendiculars drawn from points A and B to the occlusal plane.[20]

NLP—A perpendicular to NL through pm, pterygomaxillare.

The following linear measurements and angles were analyzed:

Table I. Type of ectopic eruption in each quadrant for ninety-two children

Type of ectopic eruption	*No. of children*	*No. of maxillary quadrants*		
		Irreversible ectopic eruption	*Reversible ectopic eruption*	*Normal eruption*
Irreversible				
Bilateral	24	48	—	—
Unilateral	33	33	11	22
Reversible				
Bilateral	15	—	30	—
Unilateral	20	—	20	20
Total	92	81	61	42

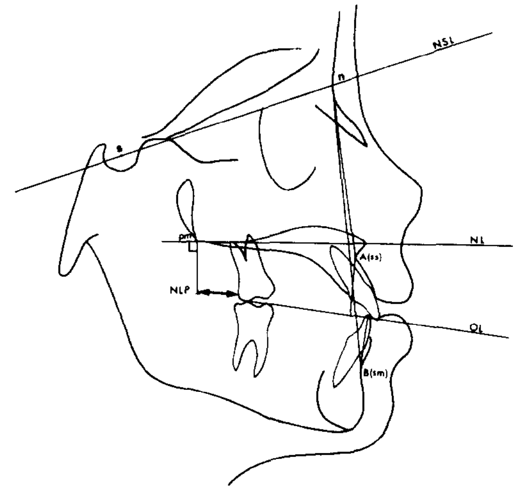


Fig. 2. Reference points and lines used for measurements on lateral head films.

ss-pm—total length of the maxilla.
NLP—distal contour of the right first permanent molar.
NLP—distal contour of the left first permanent molar.
A-B on OL—intermaxillary relationship.
s-n-ss angle.
s-n-sm angle.
ss-n-sm angle.

All measurements were made by one of us. The precision of measurement was 0.5 degree for angles and 0.1 mm. for distances. Linear measurements on the films were recorded directly without correction for enlargement.

Measurements on orthopantomograms

The orthopantomograms were used for measurements of mesial angulation of the first permanent molars. A horizontal reference line was drawn through the lowest point of the orbital fossa on both sides.

For the first permanent molar, a vertical line was drawn tangent to the crown mesially and the mesial part of the mesiobuccal root. The mesial angle between the reference line and the molar line was measured to the nearest 0.5 degree (Fig. 3). The measured angles were right first molar angle, left first molar angle, and right and left first molar angle difference.

The orthopantomograms were taken with a standardized technique.

Analysis of the observation errors for orthopantomograms

As positioning affects distortion,[21, 22] a separate study was made of distortion due to differences in head position. Four skulls were used. Orthopantomograms were obtained with 5, 10, and 15 degrees of angulation upward or downward.

The results showed that radiographs with a 5-degree change in head position upward resulted in a decrease of the measured angle (mean 2.0 degrees, S.D. = 1.58). With the head tilted downward 5 degrees, the angle increased (mean 4.0 degrees, S.D. = 1.51). With 10 and 15 degrees of angulation from the normal correct position, the films would not have been accepted clinically.

Measurements on the casts

Mesiodistal width was measured for the central incisors, the lateral incisors, and the first permanent molars in the upper jaw. All measurements were performed with sliding calipers to the nearest 0.1 mm. For linear and angular measurements, the casts were fixed in a stereograph (modified from Schwarz's model) similar to that used by Linder-Aronson.[23] The incisor cross and the cusps of the maxillary first molars were oriented in the horizontal plane. The measurement points were then transferred to a paper below the stereograph in a horizontal plane. The measurements were made by one of us.

The following linear and angular measurements were analyzed (Fig. 4):

Width of right central incisor
Width of left central incisor
Width of right lateral incisor
Width of left lateral incisor
Width of right first molar
Width of left first molar
Canine-premolar space, right side *(a)*
Canine-premolar space, left side
Alveolar arch length, right side *(b)*
Alveolar arch length, left side
Dental arch length, right side *(c)*

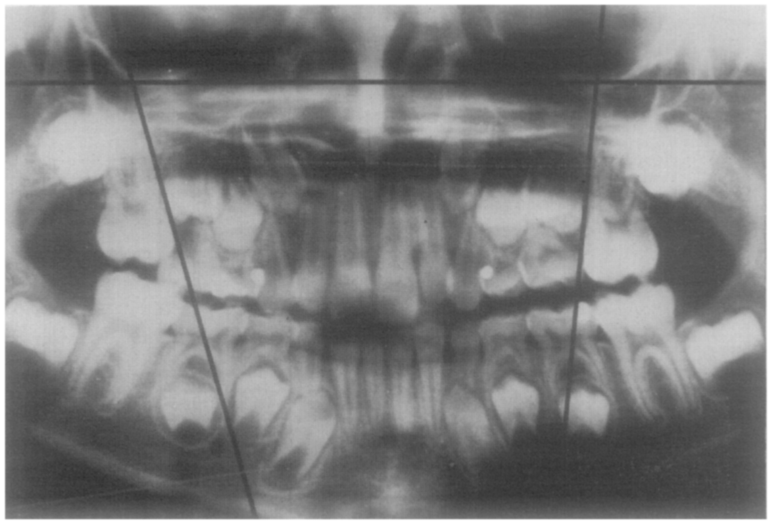


Fig. 3. Reference lines used for measurements on the orthopantomogram of the mesial angle of the maxillary first permanent molars.

Dental arch length, left side
Arch width between first molars
Arch width between deciduous canines
Right molar distance to midline *(d)*
Left molar distance to midline
Right molar rotation *(e)*
Left molar rotation
Sagittal occlusion type
Transversal occlusion type
Vertical occlusion type
Number of infra-occluded teeth

The space in the canine-premolar segments of the dental arch was measured from the mesial contact point of the first permanent molar to the mesial contact point of the deciduous canine, as the lateral incisors were frequently unerupted. The maxillary alveolar arch length was measured on both the right and left sides as the distance from the sulcus distal to the maxillary tuberosity to a line tangent to the buccal surfaces of the central incisors. Dental arch length for each side was measured as the distance from the central fossa of the right and left permanent molars to the line tangent to the buccal surfaces of the central incisors. Posterior maxillary space is thus the difference between these two measurements. The right and left molar distance to the midline of the maxilla was measured perpendicular to the maxillary midline (a line drawn through median raphe) from the central fossa of both molars.

Arch width was measured between the central fossae of both molars. Arch width in the canine region was measured between the tips of the deciduous canines. The degree of rotation of the permanent molars was measured from the maxillary midline to a line through the tips of the mesiobuccal and distolingual cusps of the first molar (Fig. 4).

For those first permanent molars which were locked distal to the second deciduous molars, tooth width was measured after extraction of the second deciduous molar and subsequent eruption of the permanent molar.

The variables of width of right lateral incisor and width of left lateral incisor were later excluded as these teeth were unerupted in several of the young children. The variables of alveolar arch length, right and left side, were also excluded because of local poor quality of the casts where the registration point at the sulcus distal to the tuberosity could not be distinguished in about one half of the children. When these variables had been excluded, the remaining variables could be measured in 104 children: 26 controls and 78 children with ectopic eruption.

For measurement, four groups were distinguished. Normal sides were divided into two groups: normal side in bilateral cases and normal side in cases in which the other side showed irreversible ectopic eruption. Irreversible ectopic eruption was measured in one group in which the other side showed normal eruption and another group in which the irreversible ectopic eruption was bilateral.

STATISTICAL METHODS

Conventional t tests were used in the method error study. In comparisons between means of the four groups, one-way analyses of variance were used.[24] For

Table II. Mean and standard deviation for the twenty-four variables in sides with normal eruption and irreversible ectopic eruption

	Normal eruption (other side normal eruption)		*Normal eruption (other side irreversible ectopic eruption)*		*Irreversible ectopic eruption (other side normal eruption)*		*Irreversible ectopic eruption (other side irreversible ectopic eruption)*	
Variables	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
1. Length of maxilla pm-ss	47.1	2.4	44.6	2.8	46.1	1.7	45.7	2.1
2. NLP-distal contour of right first molar	7.7	1.9	5.7	1.6	8.6	2.1	8.1	2.1
3. NLP-distal contour of left first molar	6.9	1.8	6.2	2.3	5.5	2.0	8.3	1.8
4. A-B on OL	−1.0	2.6	0.1	2.3	−1.1	2.6	−1.8	2.4
5. s-n-ss angle	81.5	3.4	83.4	3.2	82.4	2.1	81.5	3.4
6. s-n-sm angle	77.6	3.3	78.3	1.9	77.9	2.5	77.7	3.4
7. ss-n-sm angle	3.8	2.0	5.1	2.9	4.5	1.8	3.8	2.3
8. Right first molar angle	100.3	5.3	97.0	6.8	81.9	10.7	85.9	7.4
9. Left first molar angle	100.3	5.6	96.0	6.4	82.9	6.0	85.2	6.8
10. Right and left first molar angle difference	2.3	4.0	14.1	6.2	16.0	5.6	3.5	2.1
11. Width of right central incisor	10.4	0.5	10.7	0.7	11.0	0.5	11.0	0.5
12. Width of left central incisor	10.3	0.5	10.6	0.7	10.8	0.4	10.7	0.5
13. Width of right first molar	8.9	0.5	8.9	0.6	9.1	0.6	9.0	0.7
14. Width of left first molar	8.9	0.5	8.9	0.5	9.0	0.5	9.0	0.7
15. Canine-premolar space, right side	22.0	1.6	23.4	1.2	19.0	2.4	18.4	1.9
16. Canine-premolar space, left side	22.0	1.3	22.2	1.4	19.9	1.9	18.8	2.2
17. Dental arch length, right side	45.6	2.9	43.2	1.5	43.9	2.3	42.9	3.1
18. Dental arch length, left side	22.8	3.0	21.8	1.3	21.2	1.5	21.3	1.5
19. Arch width between first molars	23.3	3.0	22.4	1.4	20.9	0.4	21.6	1.9
20. Arch width between deciduous canines	32.6	2.2	30.8	2.2	32.5	1.7	33.3	1.9
21. Right molar distance to midline	51.0	7.0	50.4	5.3	47.4	8.3	48.9	10.6
22. Left molar distance to midline	54.1	5.8	55.3	7.1	43.1	3.5	51.6	8.2
23. Right molar rotation	35.1	2.8	33.5	3.0	31.1	2.7	32.5	1.8
24. Left molar rotation	34.5	2.3	33.2	1.7	29.7	2.6	31.8	1.8

multivariate comparisons between several potential factors causing ectopic eruption, three stepwise discriminant analyses were made.[25]

Errors of the method

The errors of measurements were estimated by duplicate determination of all measurements. The error of the method was 0.37 degree, S.D. 1.97 for angular measurements on dental casts and 0.47 degree, S.D. 1.68 for rotation of the right and left permanent molars, respectively, the corresponding t values being 1.79 and 2.66. The fairly large values for these measurements reflect the difficulty in locating the cusps of the molars.

A large t value (4.36) was recorded for the distance pm-ss, reflecting the difficulty in locating these two points on the lateral cephalograms. Together they account for the variation. Acceptable t values were recorded for other variables based on measurement from pm and ss, respectively.

In general, the error of measurement in this investigation was small and acceptable.

RESULTS

Comparison of the values from normal sides and sides with reversible ectopic eruption showed no significant differences. These groups were therefore pooled in the further analysis. Comparison between irreversible sides before and after extraction of the second deciduous molar showed a tendency toward greater canine-premolar space before extraction. The other variables showed no differences. These two groups with irreversible ectopic eruption were therefore also pooled.

Table III. Levels of significance for solitary variables in comparison between the four groups for sides with irreversible ectopic eruption and sides with normal eruption of the maxillary first permanent molar

Variable	*Significance*	
Right molar angle	0.000	***
Left molar angle	0.000	***
Right and left molar angle difference	0.000	***
Width of right first molar	0.000	***
Width of left first molar	0.000	***
NLP-distal contour of left first molar	0.000	***
NLP-distal contour of right first molar	0.014	*
Length of maxilla, pm-ss	0.018	*

***p <0.001.
**p < 0.01.
*p <0.05.

The material was thus divided into the following groups for analysis:

Group A. Children with bilateral normal sides, bilateral reversible ectopic eruption or unilateral reversible ectopic eruption in combination with a side with normal eruption. Altogether, 63 children.

Group B. Left side with irreversible ectopic eruption before or after extraction of the second deciduous molar. The right side had reversible ectopic eruption or normal eruption. Altogether, 6 children.

Group C. Right side with irreversible ectopic eruption; otherwise, as in group B. Altogether, 18 children.

Group D. Bilateral irreversible ectopic eruption of the first permanent molar. Altogether, 17 children.

Comparison of the mean value and standard deviation for each individual variable between the groups showed that the main feature of irreversible ectopic eruption was that the first permanent molar had a greater mesial eruption angle and increased tooth width (variables 8, 9, 10, 13, and 14, Table II). These differences are statistically significant as compared to the normal side (Table III). The maxilla in these cases was shorter (variable 1), and the permanent molar was situated more anteriorly in relation to the posterior nasal spine (pm) (variables 2 and 3).

No differences were found for the variables of sex, the sagittal position of the maxilla and mandible, and their relationship (s-n-ss, s-n-sm, ss-n-sm).

Although the molars were significantly larger on sides with irreversible ectopic eruption as compared to sides with normal eruption, the central incisors showed no significant difference.

No difference was found with respect to variations in occlusion, in either the transverse, vertical, or sagittal relation.

Table IV. Prediction of group membership for all measured variables

Group	*No. of cases*	*Predicted group membership (percent)*			
		A	*B*	*C*	*D*
Group A	72	97.2	0	0	2.8
Group B	9	0	77.8	0	22.2
Group C	24	4.2	0	87.5	8.3
Group D	24	8.3	12.5	0	79.2

Percent of grouped cases correctly classified 90.70 percent.

For sagittal occlusion, 70.8 percent had normal occlusion, 25.8 percent belonged to Angle Class II, and 3.4 percent belonged to Angle Class III. For transversal occlusion, 93.3 percent had normal occlusion and 5.6 percent had crossbite on at least one side and 1.1 percent had scissors bite. For vertical occlusion 80.9 percent had normal occlusion, 5.6 percent had deep bite, and 13.5 percent had open bite.

In addition, hypodontia was registrated separately. No difference was found between the test and control groups.

Comparison between children with bilateral irreversible ectopic eruption and control children showed that the first permanent molar was 0.6 mm. wider on the right side and 0.4 mm. wider on the left side in children with ectopic eruption (S.D. 0.5 in both cases).

Discriminant analysis

Discriminant analysis after twenty-one steps showed that the most important variables on sides with irreversible ectopic eruption were the greater first permanent molar eruption angle compared to normal sides and the greater molar width. The canine-premolar space on sides with irreversible ectopic eruption was therefore reduced as compared to normal sides.

Certain factors, when compared one by one, did not show significant differences in the group comparisons that were proved to be of importance as combination effects in the discriminant analysis. In the interaction between the following etiologic factors, the greatest combination effects were obtained for permanent molar angle, canine-premolar space, dental arch length, ss-n-sm angle, width of right permanent molar, distance NLP to first molar, molar rotation, s-n-sm angle, sagittal malocclusion type, and width of right central incisor.

In the discriminant analysis between the four groups for all 129 cases and all variables, the group

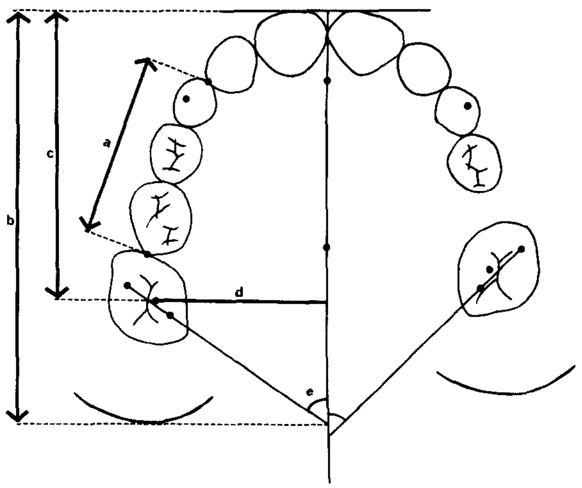


Fig. 4. Reference points used for measurements on the dental casts.

membership with respect to the measured variables could be predicted with 90.7 percent accuracy (percent of grouped cases correctly classified). (Table IV and Fig. 5). Fig. 5 shows that the groups are well separated.

With only nine of the most important variables (2, 3, 6, 7, 8, 9, 10, 13, and 14), 77.5 percent of the cases could be correctly classified with discriminant analysis between the four groups for all 129 children. As a further test of the strength of the analysis, the calculation step was performed between the four groups with all variables included in Table IV but with only 68 children randomly selected from the original number of 129. Then the classification step was performed for all of the original 129 cases. Seventy-five percent of the cases could then be correctly classified.

DISCUSSION

When can reversible and irreversible ectopic eruption of the first permanent molar be said to be present? In a recent prevalence study in children with ectopic eruption, it was found that most of these first permanent molars were locked in the atypical resorption at the distal part of the second deciduous molars at 6 years of age.[1] At 7 years most of the permanent molars in children with reversible ectopic eruption had freed themselves. Only a few of the first permanent molars which were locked at age 7 freed themselves later. It seems reasonable to conclude that the type of ectopic eruption can be reliably established between the ages of 7 and 8 years. The mean age in this material was 8 years 6 months.

As it proved difficult to construct a longitudinal axis and measure the mesial angle of the first permanent molar on lateral head films, especially in cases of unilateral ectopic eruption, the first permanent molar angle was measured on the orthopantomogram (Fig. 3). For measurements on orthopantomograms, the position of the points seemed easier to determine but distortion may occur, depending on the orientation of the head in the apparatus. A special study of the error of the method was therefore performed. In clinically acceptable orthopantomograms, the variation in head tilting affecting the molar eruption angle estimated not to exceed 5 degrees. Even allowing for this error, the mesial angle of the first permanent molar was clearly increased in cases of irreversible ectopic eruption as compared to normal eruption of the molar. It has been reported that angular measurements may be performed on orthopantomographs, provided an error of ±5 degrees is accepted.[22] The inter- and intraindividual difference between the angles in a normally erupted first permanent molar and a molar with irreversible ectopic eruption was the same, which means that the position of the patients' heads during exposure was about the same.

The increased mesial angle in irreversible cases was present before extraction of the second deciduous molar and did not increase afterward. This indicates that the eruption of the first permanent molar was mesially directed from an early stage and continued along the same path later.

Several authors have previously suggested that the length of the maxilla or poor growth in its posterior part

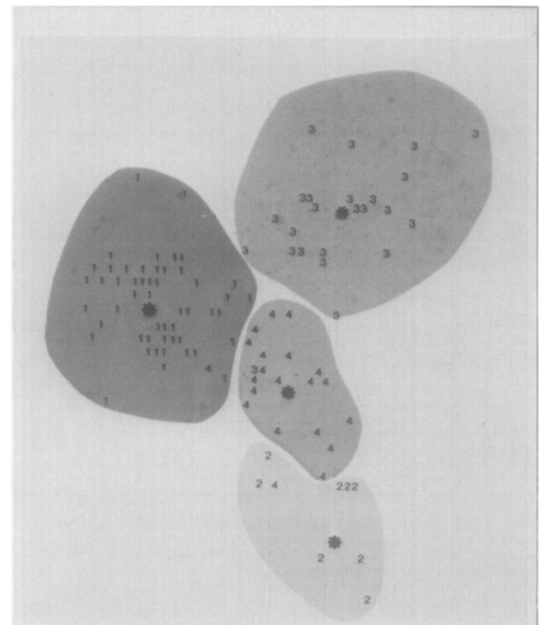


Fig. 5. Scatterplot. Canonical discriminant function. Discriminant analysis between the four groups and all variables. * indicates a group centroid. The four groups are well separated.

Am. J. Orthod.
August 1983

may play a role in ectopic eruption of the first permanent molar.[5, 9–12, 15, 26] In the present investigation this factor has been studied by measuring the distance ss-pm and the distance NLP-distal contour of the permanent molars on lateral cephalograms and the distance from the central fossa of the first permanent molar to the buccal contour of the first permanent incisors on dental casts. No significant differences in the length of the maxilla, either totally or locally in the posterior part, were found between sides with ectopic eruption of the first permanent molar and sides with normal eruption. The distance ss-pm tended, however, to be somewhat smaller in children with ectopic eruption. This is in agreement with findings in children with early loss of deciduous molars.[27]

Since the mean age of the children was somewhat more than 8 years, earlier growth disturbance in the posterior part of the maxilla cannot be excluded. An early growth disturbance posteriorly may lead to local crowding in this segment, thereby forcing the permanent molar to erupt in a more mesial direction. The development and eruption of the molar may also have been too early in relation to the growth of the alveolar process. On the other hand, the growth of the alveolar process usually depends on eruption of the teeth. The cause of the pronounced mesial inclination of the eruption path of the permanent molar cannot be established with certainty from this study, however.

As regards the length of the maxilla, differences in the children's ages may be an important factor. The mean age was 8.4 years for irreversible ectopic eruption before extraction, 8.1 years for irreversible ectopic eruption after extraction of the second deciduous molar, and 8.5 years for controls. The control children had the greatest length. The length of the maxilla in the groups with irreversible ectopic eruption before and after extraction of the second deciduous molar was the same. The biologic variation and error of measurement may explain why significant differences were not obtained.

The width of the first permanent molar was significantly greater on sides with irreversible ectopic eruption than on sides with normally erupted first permanent molars. Furthermore, in children with irreversible ectopic eruption of a permanent molar on one side, the molar on the side with normal eruption was also somewhat wider than in children with bilateral normal eruption of the first permanent molar. This increased width on the normal side was demonstrated before control sides were pooled with sides with reversible ectopic eruption. The increased width on the normal side in children with unilateral irreversible ectopic eruption suggests that several local factors interact in irreversible ectopic eruption.

It is generally considered that if the molars are large the rest of the teeth are also larger than normal. In children with ectopic eruption, the first permanent molar is wider than normal, but the incisors are not. There is therefore little possibility of using the width of the medial incisor to predict the risk of irreversible ectopic eruption. The differences in width between right and left molars remain unexplained.

First permanent molars with irreversible ectopic eruption showed a tendency to have rotated mesiopalatally. The error of measurement for these variables (23 and 24, Table II) was, however, such that no significant difference between normally and ectopically erupted molars could be demonstrated.

Pulver[5] studied possible etiologic factors and suggested that a combination of several factors could cause the ectopic eruption. Direct comparison with the present study is not possible, as the ages of the 46 children investigated varied from 4 to 12 years. Furthermore, the first permanent molar angle was measured on lateral head films, where the error of measurement may influence the result. Pulver found that in children with ectopic eruption all upper teeth were larger than normal and the maxilla was smaller than in children with normal eruption of the maxillary first permanent molar ($p < 0.05$). He suggested that children with ectopic eruption had an atypical angle of eruption and a more posterior position of the maxilla in relation to the cranial base.

The discriminant analysis in the present investigation revealed only two factors that could definitely be shown to cause ectopic eruption of the maxillary first permanent molar. These etiologic factors were increased mesial angle of the permanent molar and increased width as compared to the same measurements in children with normally erupted first permanent molars. There was also a tendency in this study toward a shorter ss-pm distance and greater rotation of the molar than in children with normal eruption (Table III). For the latter variable, however, the error of measurement was great.

It is interesting to see how well the group membership could be predicted when the prediction was based on the strength of the interaction of all variables studied; 90.7 percent of the cases could be correctly classified in this way, which must be considered a very high figure for biologic materials with a multifactorial etiology of the investigated eruption aberration. Although most of the factors studied seemed to play little or no part in the cause of ectopic eruption, the accuracy of prediction of group membership fell to 77.5 percent when only nine variables, related to five possible etiologic factors, were included in the analysis. This suggests that other factors are involved to some extent, but even 77.5 percent accuracy of prediction is high for materials with biologic variation.

A discriminant analysis was also performed with measurements from only 68 randomly sampled cases from the material in which all 129 cases were classified using all 24 variables. This analysis is the most accurate in simulating a completely randomized situation. In order to get an estimate for differences in the population, the analysis correctly classified 75 percent of the cases. This can be considered a high figure which reflects the strength of the listed etiologic factors.

REFERENCES

1. Bjerklin, K., and Kurol, J.: Prevalence of ectopic eruption of the maxillary first permanent molar, Swed. Dent. J. **5:** 29-34, 1981.
2. Young, D. H.: Ectopic eruption of the first permanent molar, J. Dent. Child. **24:** 153-162, 1957.
3. O'Meara, W. F.: Ectopic eruption pattern in selected permanent teeth, J. Dent. Res. **41:** 607-616, 1962.
4. Cheyne, V. D., and Wessels, K. E.: Impaction of permanent first molar with resorption and space loss in region of deciduous second molar, J. Am. Dent. Assoc. **35:** 774-780, 1947.
5. Pulver, F.: The etiology and prevalence of ectopic eruption of the maxillary first permanent molar, J. Dent. Child. **35:** 138-146, 1968.
6. Wäckerle-Heporauta, E.: Häufigkeit und ausmass der beim durchbruch oberer 6-jahrmolaren auftretenden unterminierenden resorptionen benachbarter milchfünfer, Thesis, Zürich, 1981.
7. Kimmel, N. A., Gellin, M. E., Bohannan, H. M., and Kaplan, A. L.: Ectopic eruption of maxillary first permanent molars in different areas of the United States, J. Dent. Child. **49:** 294-299, 1982.
8. Chapman, M. H.: First upper permanent molars partially impacted against second deciduous molars, Int. J. Oral Surg. **9:** 339-345, 1923.
9. Graber, T. M.: Orthodontics: Principles and practice, ed. 3. Philadelphia, 1972, W. B. Saunders Company, pp. 388-389.
10. Herman, E.: The malposed first permanent molar, N. Y. State Dent. J. **35:** 343-350, 1969.
11. Ravn, J. J.: Ektopisk eruption of overkaekens seksårs-molarer, Tandlaegebladet **74:** 11-16, 1970.
12. Braden, R. E.: Ectopic eruption of maxillary permanent first molars, Dent. Clin. North Am. **8:** 441-448, 1964.
13. Cardenas, G.: Ectopic eruption of the upper permanent first molar, Temas Odontol. **120:** 24-35, 1975.
14. Cossman, M. H.: Ectopic eruption: First molar impaction in the mixed dentition, Dent. Dig. **76:** 349-353, 1970.
15. McDonald, R.: Dentistry for the child and adolescent, ed. 2, St. Louis, 1974, The C. V. Mosby Company, chaps. 17 and 18.
16. Treyer, P.: Die unterminierende resorption an oberen zweiten milchmolaren beim durchbruch der oberen 6-jahrmolaren, Thesis, Zürich, 1981.
17. Kurol, J., and Bjerklin, K.: Ectopic eruption of maxillary first permanent molars: Familial tendencies, J. Dent. Child. **49:** 35-38, 1982.
18. Björk, A.: The face in profile, Sven. Tandläk. Tidskr. **40:** 32-33, 1947.
19. Solow, B.: The pattern of craniofacial associations, Acta Odontol. Scand. **24:** 25-27, 42, 1966.
20. Jacobson, A.: The "Wits" appraisal of jaw disharmony, AM. J. ORTHOD. **67:** 125-138, 1975.
21. Frykholm, A., Malmgren, O., Sämfors, K.-A., and Welander, U.: Angular measurements in orthopantomography, Dentomaxillofac. Radiol. **6:** 77-81, 1977.
22. Tronje, G., Welander, U., McDavid, W. D., and Morris, C. R.: Image distortion in rotational panoramic radiography. III. Inclined objects, Acta Radiol. **22:** 585-592, 1981.
23. Linder-Aronson, S.: The effect of premature loss of deciduous teeth, Acta Odontol. Scand. **18:** 101-122, 1960.
24. Brownlee, K. A.: Statistical theory and methodology in science and engineering, New York, 1967, John Wiley & Sons, Inc., chaps. 9 and 10.
25. Morrison, D. F.: Multivariate statistical methods, ed. 2, New York, 1976, McGraw-Hill Book Company, Ltd., chap. 6.
26. Skjeflo, A., and Zachrisson, B. U.: Ektopisk erupsjon av forste permanente molar i överkjaeven, Nor. Tanndlaegeforen. Tid. **81:** 203-210, 1971.
27. Rönnerman, A., and Thilander, B.: Facial and dental arch morphology in children with and without early loss of deciduous molars, AM. J. ORTHOD. **73:** 47-58, 1978.

Reprint requests to:
Dr. Krister Bjerklin
Institute for Postgraduate Dental Education
Department of Orthodontics
Järnvägsgatan 9
S-552 55 Jönköping, Sweden