Pre-eruptive Factors of Tooth Rotation and Axial Inclination

YOUNG H. KIM, F. R. SHIERE, and H. R. FOGELS

Forsyth Dental Infirmary and Department of Oral Pediatrics, Tufts University School of Dental Medicine, Boston, Massachusetts.

Knowledge concerning rotation of permanent teeth is based primarily on posteruptive disturbances. Habitual, mechanical, local, or environmental factors have been cited as etiologic agents. The deviated path of eruption of the permanent incisors, subsequent to traumatic injury or pathologic change, is designated as a pre-eruptive disturbance.[1, 2] Thus the rotation of permanent teeth can be divided into two categories in relation to etiologic factors: (1) rotation of permanent teeth caused by posteruptive disturbances and (2) those caused by pre-eruptive disturbances. If these pre-eruptive disturbances are significant in altering the eruptive path of the permanent incisors, it is possible that similar conditions may influence the eruption of the permanent posterior teeth. There are several adverse factors operative in the pre-eruptive phase of permanent tooth emergence, for example, (1) asymmetrical root resorption of deciduous molars, (2) pathologic involvement of deciduous roots, and (3) the early loss of the first permanent molar prior to the eruption of the adjacent premolars. Logically, these conditions can be differentiated into separate entities as they affect tooth eruption.

According to Morgan's study,[3] it was evident that if a deciduous tooth was retained beyond normal exfoliation time, the succeeding permanent tooth had a tendency to rotate. One reason for this prolonged retention was given as the incomplete resorption of deciduous roots. Another was the lack of co-ordination between the resorption process of deciduous tooth roots and the eruption process of the permanent successors. Morgan's emphasis was focused on prolonged retention as the factor responsible for rotation of the permanent successor.

Ash[2] stated that overretention of a mandibular second deciduous molar may result in a generalized malocclusion. He demonstrated that a minor irregularity of the dentition may cause a generalized dental irregularity. Malocclusions that occur from this type of minor irregularity are common.

The axial inclination of teeth must be considered when occlusion is appraised. The importance of this has been expressed by many workers in evaluating dentofacial balance and harmony.[4–7] These studies were based on axial inclination of anterior teeth, which undoubtedly do influence the profile of the face. However, the axial inclination of posterior teeth has not been fully investigated. It was shown by Marshall-Day[8] and Salzmann[9, 10] that the loss of a permanent molar or molars created abnormal drifting

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of adjacent teeth and consequently a malocclusion. Strang[11] stated that "the teeth mesial to the space either stand still, . . . may even be tipped distally into the space and an abnormal distal axial inclination of their crowns thus will be established." Such factors have been studied on the basis of posteruptive disturbances. However, the deviation of axial inclination resulting from pre-eruptive disturbances has not been described, as far as the authors are aware. The purpose of this study was to evaluate the conditions that affect rotation and axial inclination of permanent posterior teeth in the pre-eruptive stage.

MATERIALS AND METHODS

Longitudinal records of 503 cases consisting of clinical examinations, full-mouth periapical radiographs, and study models were utilized. The subjects were Caucasian children living in the New England area. From this total, 180 cases of the lower first premolars and 211 cases of the lower second premolars were selected for study. It was determined that lower premolars would provide accurate data, since the periapical radiographs display minimum distortion in these areas.

TABLE 1

TOTAL POPULATION OF LOWER FIRST AND SECOND PREMOLARS BY GROUPS

Group	R4	L4	Total	R5	L5	Total
I.....	47	47	94	47	43	90
II.....	20	15	35	22	20	42
III.....	9	8	17	24	20	44
IV.....	15	19	34	15	20	35

The premolar tooth population was divided into four groups (Table 1). Group I, the normal sample, consisted of 94 first premolars and 90 second premolars. Group II, cases which showed asymmetrical resorptions of deciduous molar roots, consisted of 35 first premolars and 42 second premolars. Group III, cases with pathologic involvement in the apical region of deciduous molars, consisted of 17 first premolars and 44 second premolars. Group IV, cases with loss of the lower first permanent molar prior to the eruption of adjacent premolars, consisted of 34 first premolars and 35 second premolars.

The chronologic age at the time of measurement was obtained for each case. The mean ages and standard deviations for each group are shown in Table 2.

The data concerning sex distribution in each group are presented in Table 3. Although the number of male and female subjects is given, the differences which might have existed in the measurement between the sexes were not analyzed because of the small size of the sample represented in Groups II, III, and IV. However, it is worthwhile to mention that male and female cases were well distributed within each group.

Rotation was expressed by the relationship of the buccolingual cusps of the lower premolars to the lower dental arch contour. The measurements were made on the study models with the aid of a clear plastic-arm protractor. They were read by placing the 90° line of the protractor directly on the centers of the buccal and lingual cusps of

the tooth and then by placing the line of the arm along or parallel to the buccal aspect of the dental arch contour (Fig. 1). When the buccal aspect of the tooth rotated toward the mesial, the measurement was read as a mesial rotation; when rotated toward the distal, it was read as a distal rotation.

In order to determine the mesiodistal or anterioposterior axial inclination of the lower first and second premolars, a direct measurement on the periapical radiograph was made. The measurement of the inclination was obtained from an axial line shown on a radiograph, which runs from the center of the cusp to the apex and an occlusal line

TABLE 2

MEAN CHRONOLOGIC AGES AND STANDARD DEVIATIONS OF LOWER PREMOLARS

GROUP	FIRST PREMOLARS		SECOND PREMOLARS	
	Mean Age (Years)	S.D.	Mean Age (Years)	S.D.
I	12.24	0.67	12.23	0.72
II	12.07	0.76	12.21	0.73
III	11.80	0.91	11.79	1.00
IV	12.51	0.77	12.54	0.78

TABLE 3

SEX DISTRIBUTION OF LOWER PREMOLARS

GROUP	FIRST PREMOLARS			SECOND PREMOLARS		
	Male	Female	Total	Male	Female	Total
I	50	44	94	49	41	90
II	20	15	35	27	15	42
III	9	8	17	26	18	44
IV	17	17	34	18	17	35

drawn tangential to the cusps of the posterior and canine teeth (Fig. 2). When the coronal portion of the tooth was tipped mesially, it was read as an angle greater than 90°, and, when tipped distally, it was read as an angle less than 90°.

RESULTS

Significant rotations in the erupting lower premolars were observed by using the method previously described (Table 4). In Group I, less than 3° of rotation was found. The severity of rotation increased progressively through Groups II, III, and IV, and rotation of the second premolar was greater than that of the first premolar. According to the *t*-tests, these differences were found to be significant at the 1 per cent level of confidence.

It was observed in Group III (Table 5) that some cases showed pathologic lesions for more than one year and others for a shorter period of time. By subgrouping these

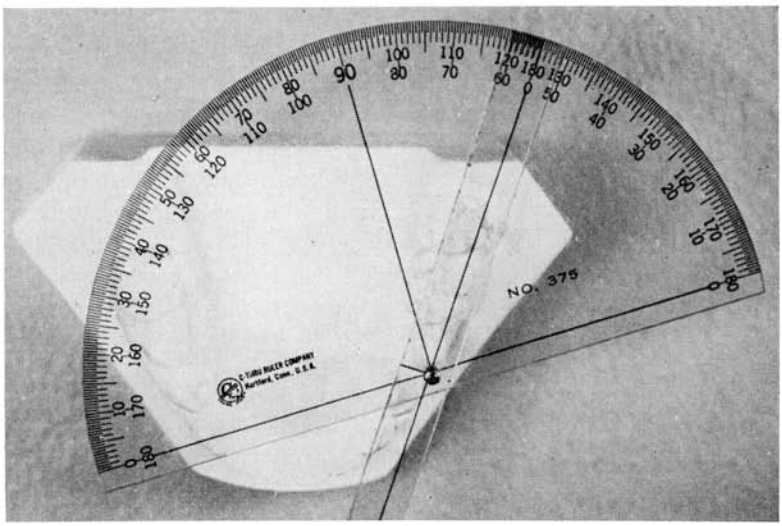

FIG. 1.—Measurement of tooth rotation for the lower left second premolar. The measurement indicates 55° of mesial rotation.

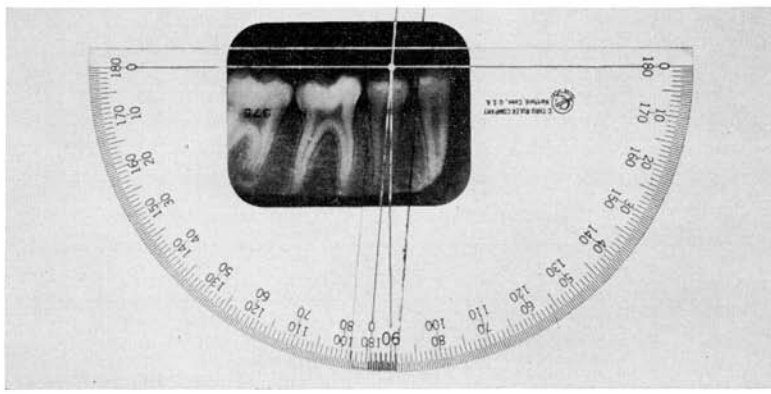

FIG. 2.—Measurement of axial inclination of the lower left second premolar. The measurement indicates 94.5° of axial inclination in relation to the occlusal line.

TABLE 4

DEGREES OF ROTATION OF LOWER FIRST AND SECOND PREMOLARS

GROUP	LOWER FIRST PREMOLARS			LOWER SECOND PREMOLARS		
	Mean	S.D.	*t*	Mean	S.D.	*t*
I.....	2.03°	3.38	.....	2.79°	3.63	.....
II.....	6.26°	5.87	5.615	11.90°	8.13	8.373
III.....	11.71°	7.12	6.993	23.57°	17.71	10.584
IV.....	12.66°	10.21	7.819	25.59°	16.63	11.299

two separate entities, it was found that the severity of rotation in the former (subgroup A) differed from that of the latter (subgroup B). Analysis showed that in cases of the first premolar the mean rotation of subgroup A was 18.17°, in contrast to 8.18° of mean rotation shown in subgroup B. The difference of mean values was found to be significant at the 1 per cent level. In cases of the second premolar, the mean rotations of subgroups A and B were 29.05° and 18.57°, respectively, which was significant at the 5 per cent level.

The approximate age at which a pathologic lesion occurred was determined for each case in Group III. This analysis revealed the most frequent age when this condition

TABLE 5

ROTATION OF FIRST AND SECOND PREMOLARS IN SUBGROUPS OF GROUP III

	Subgroup A			Subgroup B			
	No.	Means	S.D.	No.	Means	S.D.	*t*
First premolars	6	18.17°	4.72	11	8.18°	5.59	3.87
Second premolars	21	29.05°	2.37	23	18.57°	10.17	2.14

TABLE 6*

FREQUENCY OF ROTATION OF FIRST AND SECOND PREMOLARS DIFFERENTIATED BY DIRECTION OF ROTATION (PER CENT)

Group	Lower First Premolars			Lower Second Premolars		
	M/R	D/R	N/R	M/R	D/R	N/R
I	41	8	51	29	24	47
II	63	26	11	79	21	0
III	76	12	12	80	20	0
IV	71	29	0	60	38	2

* M/R = mesial rotation; D/R = distal rotation; N/R = no rotation.

was initiated. The average age was 7.99 years, standard deviation 0.94, for the first premolars, and 8.22 years, standard deviation 1.21, for the second premolars.

Since teeth rotate either mesially or distally, it was necessary to evaluate the frequency of the direction of rotation. This was divided into three categories: mesial, distal, and no rotation (Table 6). According to the data, there was a strong indication that the lower first and second premolars had a characteristic tendency to rotate in a mesial direction.

In order to correlate tooth rotation with eruption age, the supragingival eruption age of each tooth was determined. Mean eruption age and standard deviations were obtained (Table 7). There was no significant correlation between the eruption age and the rotation of erupting premolars.

These data were then compared with those of Hurme.[12] In all groups, the analysis

of the mean eruption ages of the lower first and second premolars corresponds with Hurme's normal range of variation.

In the lower first premolar, Group III demonstrated the earliest eruption time, while, in the lower second premolar, Group II preceded the others in eruption. It is of interest to note the delayed eruption following the loss of the first permanent molar (Group IV).

TABLE 7

COMPARISON BETWEEN MEAN ERUPTION AGES

Group	Mean (Years)	S.D.	Hurme's Mean* (Years)
	Lower First Premolars		
I	10.27	0.82	10.50
II	10.28	0.87	
III	10.00	0.98	
IV	10.69	0.66	
	Lower Second Premolars		
I	10.98	0.85	11.18
II	10.04	0.88	
III	10.80	1.01	
IV	11.16	0.92	

* The mean of boys and girls.

TABLE 8

DEGREES OF AXIAL INCLINATION OF LOWER FIRST AND SECOND PREMOLARS

Group	Lower First Premolars			Lower Second Premolars		
	Mean	S.D.	t	Mean	S.D.	t
I	88.90°	2.39	.....	92.76°	2.36	.....
II	88.31°	2.32	1.265	93.29°	2.70	0.112
III	88.44°	3.72	0.571	91.74°	4.12	1.711
IV	83.71°	5.19	6.342	88.00°	5.46	6.111

The purpose and the method of analyzing axial inclination of lower premolars was mentioned previously. Data analysis is shown in Table 8.

It was found that the axial inclination of the first premolars was slightly less than a right angle (distal tipping), whereas that of the lower second premolars was slightly greater than a right angle (mesial tipping). Also, there was no significant difference between the means of the normal group and the means of the other groups, with the exception of Group IV. When the mean of this group was compared with the mean of

the normal group, 5° less angulation in both the first and the second premolar cases was demonstrated. This was significant at the 1 per cent level of confidence.

DISCUSSION

Examination of the results reveals that rotation of permanent teeth can occur in the pre-eruptive stage of development. Morgan[3] stated that prolonged retention of primary teeth was one cause of rotation. The present study, in addition, demonstrated that there were other contributing factors, such as asymmetrical root resorption, pathologic involvement of deciduous molars, and the premature loss of the first permanent molar. It was shown in Group II that there was significant rotation of permanent teeth, but that prolonged retention did not appear to be a cause of rotation. However, the retention of the deciduous root tips in Figures 3 and 4 (Case 3) may contribute to the rotation of the second premolar. Group III showed severe tooth rotations,

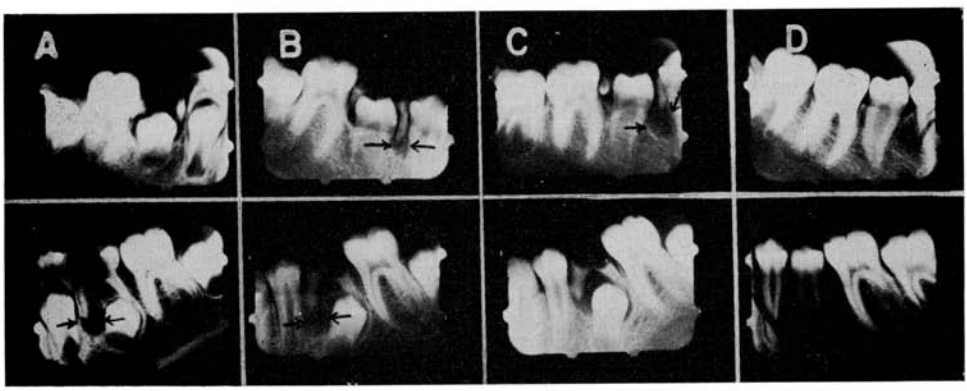

FIG. 3.—Roentgenograms (*upper series—left; lower series—right*) showing radiolucent lesions deviating the eruption pathway of lower second premolars. Case #3 at *A*, 9.1 years; *B*, 10.1 years; *C*, 11.2 years; *D*, 12.2 years.

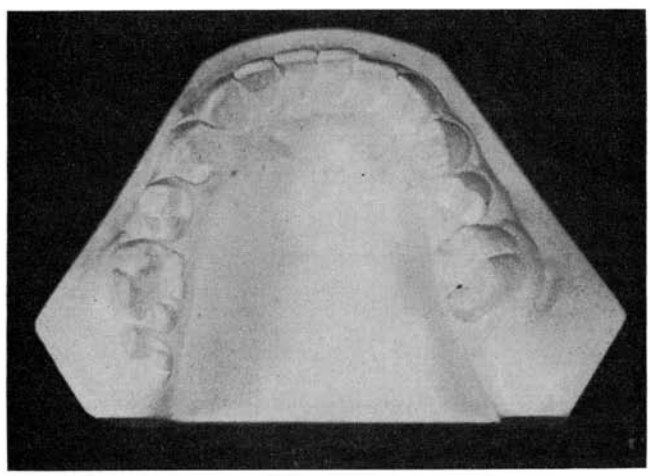

FIG. 4.—Cast taken at 12.2 years showing severity of rotation of second premolars

whereas Group IV demonstrated not only severe rotations but also considerable axial deviation.

Permanent tooth rotations analyzed in Group III may result from pathologic lesions or fluid pressure in the deciduous root area. It is possible that these pressures may be transmitted directly to the dental sac or tooth bud, with the result that the permanent tooth becomes rotated. This response takes place in a direction opposite to the applied force and may alter the pathway of eruption by the interaction of the eruptive forces and the pressure from the pathologic process.

Figures 3 and 5 demonstrate clearly the radiolucent lesions in close approximation to, or in contact with, permanent teeth.

The results of this investigation offer evidence that teeth which cannot be restored to a normal healthy condition should be extracted.

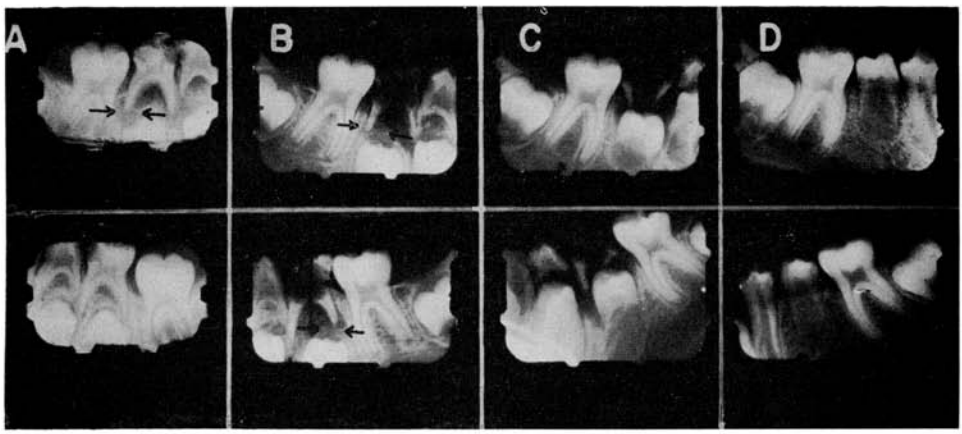

FIG. 5.—Roentgenograms (*upper series—left; lower series—right*) showing increasing severity of rotation of lower left second premolar. Case #144 at *A*, 6.3 years; *B*, 7.3 years; *C*, 8.4 years; *D*, 12.2 years.

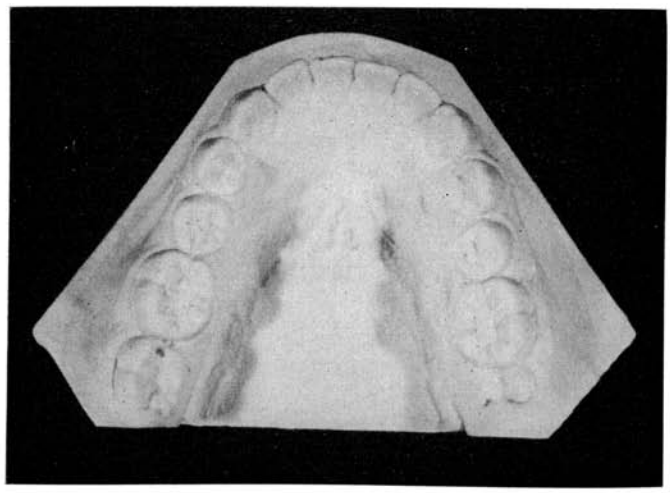

FIG. 6.—Cast taken at 10.4 years showing rotation of second premolar

In conjunction with the loss of the first permanent molar (Group IV), it was found that premolars not only rotate but also incline distally. Therefore, the extraction of the first permanent molar prior to the eruption of the adjacent premolars should be avoided if possible.

SUMMARY

This investigation was undertaken to determine the pre-eruptive causes of rotation and the axial inclinations of the lower premolars. Angular measurements were obtained directly from the study models and radiographs with the aid of an arm protractor. From 503 longitudinal case records, 180 cases of the lower first premolars and 211 cases of the lower second premolars were selected for study.

In Group I, the normal sample, less than 3° of mean rotation was found in both erupting first and second premolars. The mean axial inclinations were 88.90° for the first premolars and 92.76° for the second premolars.

In Group II, the mean rotations were 6.26° for the first premolars and 11.90° for the second premolars. The differences of the means were found to be significant at the 1 per cent level of confidence when compared with the means of the normal sample. The mean axial inclinations were 88.31° and 93.29° for the first and second premolars, respectively, and no significant difference was found between the means of Groups I and II.

In Group III, the mean rotations were 11.71° for the first premolars and 23.57° for the second premolars. The mean differences between this group and the normal sample were found to be significant at the 1 per cent level of confidence. It was also found that cases which had lesions in the deciduous molar root area for more than one year showed significantly greater mean rotations than those which had lesions for less than one year. The means of axial inclination were 88.44° for the first premolars and 91.74° for the second premolars.

In Group IV, the mean rotations were 12.66° and 25.59° for the first and second premolars, respectively. The mean differences between this group and Group I were also found to be significant at the 1 per cent level of confidence. The mean axial inclinations were 83.71° and 88.00° for the first and second premolars, respectively. These mean axial inclinations were found to be significantly different at the 1 per cent level of confidence when compared with the normal group.

In general, it was found that the lower first and second premolars had a characteristic tendency to rotate in a mesial direction. This tendency, as well as the severity of rotation, was found to be greater in second premolars than the first premolars.

It was concluded that (1) the preservation of a deciduous molar with apical pathology is contraindicated, and (2) the extraction of the lower first permanent molar prior to the eruption of adjacent premolars should be avoided, if possible.

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