Original Article

Statistical Evaluation of Possible Factors Affecting the Sagittal Position of the First Permanent Molar in the Maxilla

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Abstract: A cephalometric analysis was designed to evaluate several factors that may affect the sagittal position of the maxillary first permanent molar. A total of 184 Class II and Class I malocclusion patients were randomly selected before orthodontic treatment. The mandibular and palatal planes were related to Frankfort Horizontal and used to create the interjaw or B angle. Age and cephalometric landmarks (Ba, N, point A, pterygomaxillary fissure, and maxillary molars) were projected at right angles to the Frankfort Horizontal for effective length. Actual maxillary length and actual molar location were determined by projecting landmarks at right angles to the palatal plane. Correlation coefficients and P values were used to evaluate the data with a minimal significance value of .05 to determine a 95% confidence level. A statistically significant linear and proportional positive correlation ($P < .0001$) existed between molar location, age, and maxillary size. There was a strong negative correlation ($P < .0001$), both linearly and as a proportion of the actual length of the maxilla, between the actual position of the maxillary molar and the interjaw and mandibular plane angles. A significant correlation also existed between the molar position and palatal plane angles. The results show that increased interjaw, mandibular, and palatal plane angles are accompanied by a more posterior position of the maxillary first molar in the maxilla, whereas the molar occupied a continuing more forward position in the maxilla with increasing age, cranial base length, and maxillary size. (*Angle Orthod* 2004;74:220–225.)

Key Words: Correlation coefficients; *P* values; Maxillary molar; Interjaw; Mandibular and palatal plane angles

INTRODUCTION

The introduction of Angle's classification of malocclusion in the late 19th century has frequently been referred to as the most important influence in bringing order out of chaos in orthodontics.[1] He stated that the maxillary first molar . . . ''furnishes more nearly than any other tooth or point in the anatomy an exact scientific basis from which to reason on malocclusion.'' The second chapter of Angle's seventh edition is on malocclusion, where he presented and discussed the classification of malocclusion. In Angle's classification, normal occlusion exists when the mesiobuccal cusp of the upper first molar . . . ''is received in the buccal grove of the lower first molar.'' He describes Class II malocclusion as follows: ''when from any cause the lower first molars lock distally to normal with the upper first molars on their eruption of the extent of more than half the width of one cusp on each side, it must necessarily follow that every succeeding permanent tooth to erupt must also occlude abnormally, all the lower teeth being forced into position of distal occlusion thereby causing more or less retrusion or lack of development or both of the entire jaw.''[2]

Angle, therefore, believed that malocclusions are of mandibular origin. There has been an abundance of literature relative to the etiology of all classes of malocclusions. They range from dental to skeletal both in size and position and in interrelationship of parts.[1–19] The purpose of this investigation was to test several null hypotheses that may affect the position of the maxillary first molar in the maxilla irrespective of the class of malocclusion and the possible interaction of the factors themselves.

- The chronologic age will have no effect on the position of the maxillary first molar in the maxilla.

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Accepted: May 2003. Submitted: January 2003.

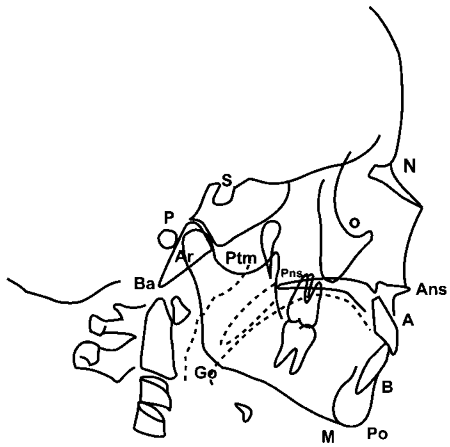

FIGURE 1. Cephalometric landmarks.

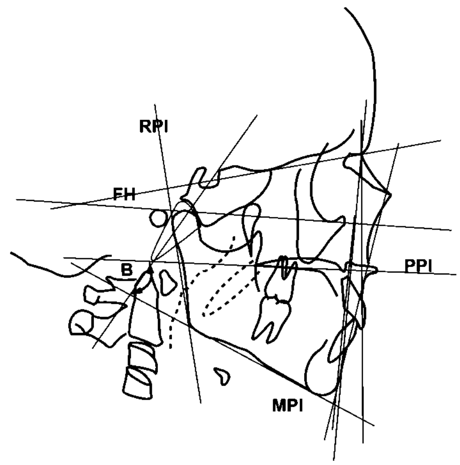

FIGURE 2. Cephalometric planes and B interjaw angle.

- The interjaw or ''B'' angle will have no effect on the position of the maxillary first molar in the maxilla.
- The angulation of the palate, as determined by its relationship to Frankfort Horizontal, will have no effect on the position of the maxillary first molar in the maxilla.
- The mandibular plane angulation, as determined by its relation to Frankfort Horizontal, will have no effect on the position of the maxillary first molar in the maxilla.
- The length of the cranial base will have no effect on the position of the maxillary first molar in the maxilla.
- The location of the maxilla on the anterior cranial base will have no effect on the position of the maxillary first molar in the maxilla.
- The length of the maxilla will have no effect on the position of the maxillary first molar in the maxilla.

MATERIALS AND METHODS

Each lateral cephalometric radiograph was traced with a 4H graphite pencil on matte acetate tracing paper. Both midline and bilateral images were traced, with all bilateral images bisected and thereafter treated as midline structures. Linear measurements were read to the nearest 0.5 mm, and all angular measurements were obtained with a standard protractor and read to the nearest 0.5°. A right angle coordinate system as described by Coben[20] was used to determine proportions. A total of 184 Class II and Class I patients (mean age 9.7 years ± 2 years SD) were randomly selected before orthodontic treatment. Gender differences were not taken into consideration.

Cephalometric landmarks and measurements

The planes and landmarks used are presented in Figures 1 and 2. Cephalometric landmarks, basion (Ba), nasion (N), pterygomaxillary fissure (PTM), point A (A), and the midbuccal groove of the maxillary first molar (U6), were projected at right angles to the Frankfort Horizontal for effective length (Figure 3). Actual length measurements were

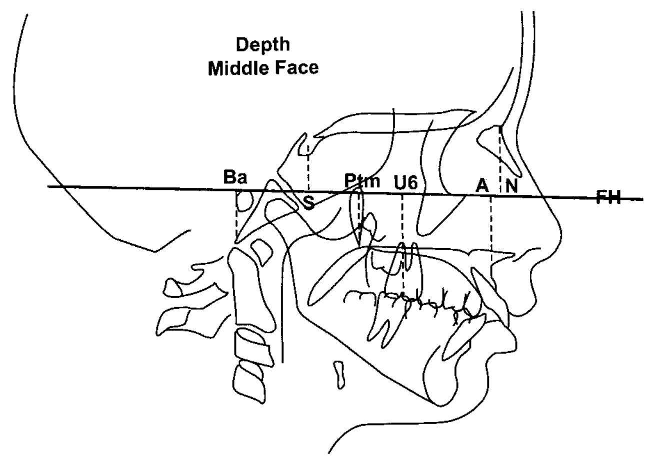

FIGURE 3. Middle face depth projected at right angles to the Frankfort Horizontal.

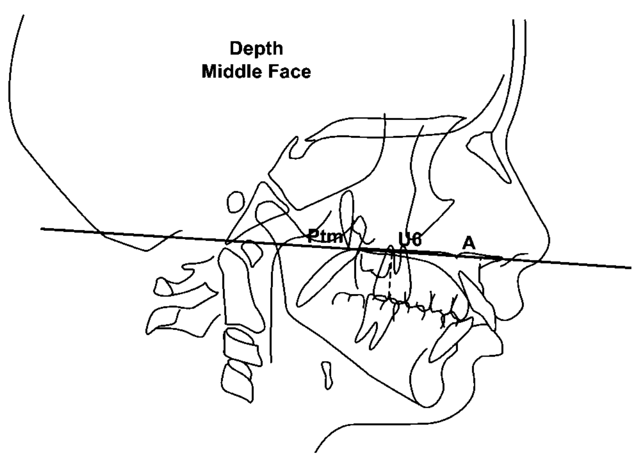

FIGURE 4. Middle face depth projected at right angles to palatal plane.

TABLE 1. Age with Correlations and Significance Levels to the Linear and Proportional Location of the Maxillary First Molar

Age Correlations	Correlation Coefficient	*P*
Age and PTM-U6 mm†	0.4862	<.0001
Age and PTM-U6 mm‡	0.5129	<.0001
Age and PTM-U6 mm % BaN†	0.4484	<.0001
Age and PTM-U6 % PTM-A†	0.501	<.0001
Age and PTMU6 % PTM-A‡	0.5263	<.0001

† As projected to FH[20]
‡ Actual length

TABLE 2. Interjaw (B) Angular Values with Correlation and Significance Levels to Both the Palatal and Mandibular Plane Angles and to the Linear and Proportional Locations of the Maxillary First Molar

Interjaw (B) Correlations	Correlation Coefficient	*P*
B and PPL angles	0.2823	<.0001
B and MPL angles	0.844	<.0001
B angle and PTM-U6 mm†	−0.2213	.05
B angle and PTM-A mm‡	−0.2348	.05
B angle and PTM-U6 mm‡	−0.3355	<.0001
B angle and PTMU6 % PTM-A‡	−0.3114	<.0001

† As projected to FH[20]
‡ Actual length

TABLE 3. Palatal Plane (PPL) Angular Values with Correlation and Significance Levels to the Mandibular Plane Angle and to the Linear and Porportional Location of the Maxillary First Molar Relative to Both the Cranial Base and Maxillary Linear Lengths

Palatal Plane (PPL) Correlations	Correlation Coefficient	*P*
PPL and MPL angles	−0.26603	.003
PPL and PTM U6 mm‡	−0.22727	.05
PPL and PTM U6 % BaN†	0.216465	.05
PPL and PTMU6 % PTM-A†	0.201703	.05
PPL and PTMU6 % PTM-A‡	−0.22411	.05

† As projected to FH[20]
‡ Actual length

TABLE 4. Mandibular Plane (MPL) Angular Values with Correlations and Significance Levels to Linear and Proportional Location of the Maxillary First Molar to Both the Cranial Base and Maxillary Linear Lengths

Mandibular Plane (MPL) Correlations	Correlation Coefficient	*P*
MPL and PTMU6 mm†	−0.32047	<.0001
MPL and PTMU6 mm‡	−0.21688	.05
MPL and PTMU6 % BaN†	−0.27174	.003
MPL and PTMU6 % PTM-A†	−0.29567	<.0001

† As projected to FH[20]
‡ Actual length

TABLE 5. Cranial Base Linear Length with Correlations and Significance Levels to the Maxillary Location, Maxillary Linear Length and to Both the Linear and Proprotional Location of the Maxillary First Molar

Cranial Base (BaN) mm Correlations	Correlation Coefficient	*P*
BaN and Ba-PTM mm†	0.7850	<.0001
BaN and PTM-A mm†	0.7030	<.0001
BaN and PTMU6 mm†	0.4816	<.0001
BaN and PTM-A mm‡	0.6799	<.0001
BaN and PTMU6 mm‡	0.45162	.05
BaN and PTM-A % BaN†	−0.218	.05
BaN and PTMU6 % PTM-A†	0.2557	.0004
BaN and PTMU6 % PTM-A‡	0.2658	.0003

† As projected to FH[20]
‡ Actual length

made by projecting landmarks PTM, U6, and A at right angles to the palatal plane, thereby eliminating the angulation of the palatal plane used in establishing effective length dimensions (Figure 4). The mandibular (MPL), palatal plane (PPL), and the interjaw or B[21,22] angles relative to the Frankfort Horizontal were recorded. Statistical analyses included calculating linear correlation coefficients and performing Student's *t*-tests. Only those *P* values below .05 were considered significant. Analyses were performed using Excel and SAS Version 8.02.

Thirteen angular, linear, and proportional measurements were determined for each patient. The angular measurements were as follows: ANSPNS/FH, MPL/FH, ANSPNS/MPL. The horizontal linear measurements were Ba-N, Ba-PTM, PTM-A, PTM-U6, PTM-A (AL), and PTM-U6 (AL). A right-angle coordinate system was used to determine proportional data.[20] The proportional measurements (Figures 3 and 4) were PTM-A % BaN, PTM-U6 % BaN, PTM-U6 % PTM-A, PTM-U6 (AL) % PTM-A (AL). A total of 2576 data were recorded.

RESULTS

As would be expected, Table 1 shows a strong positive linear and proportional correlation between age and the position of the maxillary molar in the maxilla with a *P* value of $<.0001$. The older patient has a more forward position of the maxillary first molar in the maxilla.

Table 2 shows a significant positive correlation between the B angle and PPL and MPL, with a much stronger correlation between the B angle and the mandibular plane. There is a significant negative correlation between both the effective and actual position of the maxillary molar and the B angle and between the actual length of the maxilla and the B angle ($P = .05$). The same significant negative correlation exists when the actual proportional position of the molar to the maxilla is related to the B angle.

Table 3 shows a significant negative correlation between PPL and MPL. A positive correlation occurs between PPL and the proportional position of the maxillary molar to both the cranial base and maxillary lengths, indicative of an effective more forward position of the maxillary molar in the

TABLE 6. Maxillary Location on the Cranial Base with Correlations and Significance Levels to the Linear and Proprotional Length of the Maxilla and the Linear Location of the Maxillary First Molar

Maxillary Position Correlations	Correlation Coefficient	*P*
Ba-PTM and PTM-A mm†	0.4746	<.0001
Ba-PTM and PTM-U6 mm†	0.3278	<.0001
Ba-PTM and PTM-A mm‡	0.4831	<.0001
Ba-PTM and PTM-U6 mm‡	0.3012	<.0001
Ba-PTM and PTM-A % BaN†	−0.3038	<.0001

† As projected to FH[20]
‡ Actual length

TABLE 7. Maxillary Linear Length with Correlations and Significance Levels to Both the Linear and Proportional Locations of the Maxillary First Molar, and to Linear and Proprotional Maxillary Length Both as Effective and Actual Length Measurements

Maxillary Length mm Correlations	Correlation Coefficient	*P*
PTM-A and PTMU6 mm†	0.6713	<.0001
PTM-A and PTM-A mm‡	0.9508	<.0001
PTM-A and PTMU6 mm‡	0.5804	<.0001
PTM-A and PTM-A % BaN†	0.5178	<.0001
PTM-A and PTMU6 % BaN†	0.4195	<.0001
PTM-A and PTMU6 % PTM-A†	0.331	<.0001
PTM-A and PTMU6 % PTM-A‡	0.3033	<.0001

† As projected to FH[20]
‡ Actual length

face and in the maxilla with larger palatal plane angles. In contrast, a significant negative correlation ensues when the actual position in millimeters and the actual proportional position to the maxillary length are related to PPL. The effective proportional position of the molar is located more forward with a larger PPL, whereas the actual position is the reverse, being more posterior.

Table 4 displays significant negative correlations both linearly and proportionally between the maxillary molars position and MPL. The larger the MPL, the more posterior the maxillary molar will be located. The most significant correlations occur with both the effective linear position and the proportional position relative to the length of the maxilla.

There is a significant positive correlation between effective maxillary position, maxillary length and molar position, and the length of the cranial base (Table 5). The same significant positive correlation occurs with actual maxillary length and molar position. A significant positive correlation is present in the relation of actual and effective molar position as a proportion of maxillary length. The only significant negative correlation occurs in relating the length of the cranial base to the proportional effective length of the maxilla. A long cranial base would have a proportional shorter maxillary length, indicating the possibility of muscular factors acting on the alveolar base.

There is a significant positive correlation between both the actual and effective lengths of the maxilla and the maxilla's position on the anterior cranial base (Table 6). The same positive correlation exists with both the actual and effective positions of the maxillary molar in the maxilla to the maxilla's position on the anterior cranial base. The more forward the maxilla is located, the more forward the molar will be located on a larger maxilla. A significant negative correlation is seen between the proportional length of the maxilla to the cranial base and the maxilla's position on the anterior cranial base, indicating that a shorter proportional maxillary apical base relative to the cranial base length would accompany a more forward-positioned maxilla. This corresponds with the previous finding of a proportionally shorter maxilla relative to a long cranial base.

Table 7 shows that there is a significant positive correlation between the effective maxillary length and the effective and actual locations of the maxillary molar. A positive correlation also exists between the effective molar's proportional position to both the maxillary and the cranial base lengths and to its actual proportional position to the actual maxillary length.

DISCUSSION

There were no significant correlations relating age to the three angles studied or maxillary size and position and cranial base length that may be indicative of the maintenance of the inherent facial pattern.[23] In contrast, the positive correlations relative to the maxillary molar's position would indicate a definite forward positioning of the molar with age, which exceeds cranial base and maxillary development as indicated by the molar's larger proportional value to these changing reference lengths.

Although the significance level, of both PPL and MPL were identical when related to B, the positive correlation coefficient was greater with MPL as would be expected with the greater standard deviation in MPL recorded norms.[20,24,25] An increasing interjaw angle, therefore, would more likely be the result of an increasing mandibular than palatal plane. The negative correlation coefficients in locating maxillary molar position were both higher and significantly greater using actual length dimensions and proportions than effective length, demonstrating the variance of the molar's position in the face differing from the molar's position in the maxilla.

The significant negative correlation of PPL to MPL dictates that both the mandible and maxilla are in unison in their growth direction—either down and back or up and forward—because the palatal plane angle is considered positive when anterior nasal spine (ANS) is superior to posterior nasal spine (PNS). The significant negative correlation of the actual molar position, when related to the PPL and MPL (Tables 3 and 4), is not as significant as B correlation because B is a combination of both, thereby illustrating the additive effect. The validity of using actual

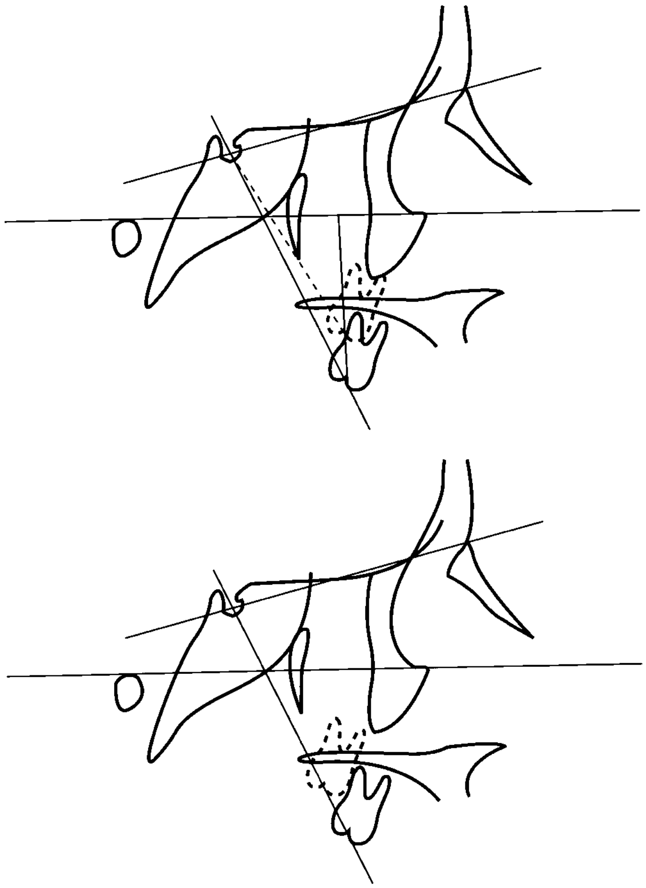

FIGURE 5. (A) Identical molar anteroposterior positions—different angular. (B) Different molar anteroposterior positions—identical angular.

length measurements in contrast to effective length is seen again, where a significant positive correlation exists when relating PPL to the proportional position of the molar to both the cranial base and maxillary length and negative correlation when using actual lengths. As the PPL increases, the molar's effective position is proportionally more forward relative to the cranial base and maxillary length. In contrast, as the PPL increases, the actual molar position is more posterior, both linearly and proportionally in the maxilla. This explains the orthopedic effect in cervical traction correction of a Class II malocclusion. The molar may be in the same position in the maxilla, but the maxilla and, therefore, the molar occupy a different relationship to the craniofacial complex.[26] In contrast, the maxillary molar's position as determined by the mandibular plane is negatively significant both in actual and effective positions (Table 4).

The only significant negative correlation when relating data to the length of the cranial base occurred in the proportional size of the maxilla relative to cranial base length, which suggests that additional forces, such as facial musculature, may have a restraining effect on maxillary size.[27] The restricting action of the superior constrictor of the pharynx, buccinator, and orbicularis oris complex on the incisors may inhibit the advancement of the maxillary alveolar base as depicted by point A. A long linear maxillary length is accompanied by a long cranial base but is proportionally smaller, advancing the use of proportions rather than linear measurements.[20] The maxillary molar occupies a more forward position both linearly and proportionally with a longer cranial base (Table 5) and with a more forward-positioned maxilla (Table 6). The proportional length of the maxilla is reduced with a more forward-positioned maxilla in contrast to both the effective and actual linear dimensions (Table 6). This once again demonstrates the possible advantage of working with proportions and the possible restricting action of the facial musculature.

Only positive correlations are present when the linear length of the maxilla is related to all the other linear and proportional data. The positive correlation of maxillary size as a proportion of cranial base length (PTM-A % BaN) relative to maxillary length (PTM-A) is not contradictory to negative correlations as seen in Tables 5 and 6. A longer maxilla is associated with a longer cranial base length and a more forward maxilla both linearly and proportionally. In contrast, Table 5 indicates that as the cranial base length increases, maxillary proportion to cranial base decreases, and as the maxilla is positioned more forward, its proportion to cranial base length decreases (Table 6).

Previous studies that found a stable position of the maxillary molar in different classes of malocclusion used angles to locate the molar's position.[3,6] Angular values have an advantage of being proportional and are not affected by linear variation brought on by individual size differences. Unfortunately, it would be improper to use angles when studying variations in one plane of space. Angles require two arms and three reference points that must be in two planes. For example, in Figure 5A, a common reference point on the maxillary first molar in two patients relative to a common reference plane is located in the same anteroposterior position. If the reference points were located at different vertical levels, the angular readings would differ. This would be interpreted as indicating that the two points were at different anteroposterior positions, when in reality, the difference was vertical and not anteroposterior. In contrast, in Figure 5B, an identical N-S–U6 reading in degrees in two patients would place both molars in the same anteroposterior position relative to the anterior cranial base but only if they were located at the same vertical distance from the nasion sella plane. The short-faced patient with a higher molar position would actually have his tooth located more posteriorly when compared with the long-faced patient with a lower molar position even though both had the same cranial base–molar angular reading.[28,29]

CONCLUSIONS

The seven null hypotheses were found to be invalid because all the variables affected the position of the maxillary molar in the maxilla with both positive and negative correlations. Age, cranial base length, maxillary position, and maxillary length had positive, statistically significant correlations with molar position, placing the molar more forward as their dimensions increased. All three angular variables had a negative, statically significant relation to the maxillary molar's position in the maxilla. As the angles increased, the molar was located more posteriorly. As an instrument is forced posteriorly toward the axis of a wedge, the arms of the wedge would be separated. This could lead to a belief that the lack of space would force the maxillary molar to occupy a more forward position. The assumption that larger palatal and mandibular plane angles and the larger interjaw angle were the result of a lack of posterior face height might be false. A follow-up study is in progress to evaluate whether the increased mandibular and palatal plane angles may be the result of an increase in anterior face height and not lack of posterior height.

The significant negative correlations of maxillary length to cranial base depth could be indicative of the superior constrictor, buccinator, and orbicularis oris complex restricting forward development of the maxillary alveolar base.

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