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Third Molar Eruption Prediction

Michael L. Jacobsen

ABSTRACT

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The diagnosis and treatment of third molars has often been cited as a special problem to the orthodontist. If the prognosis of third molars could be determined, orthodontic treatment could progress on a more positive basis.

This study was designed to provide a method of deciding whether developing third molars will erupt or become impacted.

Records from 130 orthodontically treated cases of Dr. Fredsall[8] were studied. Several factors were evaluated and measured using the patients' cephalometric radiographs.

The actual fate of the third molars were recorded in the hope it could be used to predict what to expect from the known T1 positions. Data was subjected to computer analysis for means, standard deviations and discriminant analysis.

The patients were divided into three groups: impacted, nonimpacted and a midrange or unknown group. Within each group was a further division of extracted bicuspids and non-extracted bicuspids.

The discriminant analysis revealed two variables, the

distance from Xi to the distal of the maxillary second molar and the size of the mandibular third molar, as being the best predictors for establishing eruption or impaction of the third molars. The analysis was able to predict 75.8% of the impacted cases and 69.6% of the erupted cases. This shows there is a high degree of success in being able to predict the prognosis of third molars.

LOMA LINDA UNIVERSITY

Graduate School

THIRD MOLAR ERUPTION PREDICTION

by

Michael L. Jacobsen

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of the Requirements for the Degree Master of Science
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Each person whose signature appears below certifies that this thesis, in his opinion, is adequate, in scope and quality, as a thesis for the degree of Master of Science.

_______________, Chairman
Roland D. Walters, Professor and Chairman,
Department of Orthodontics

____
Joseph M. Caruso, Assistant Professor,
Department of Orthodontics

____
Gary Engel, A.B., M.S.

____
Lawrence E. McEwen, Assistant Professor,
Department of Orthodontics

____
Dale B. Stringer, Assistant Professor,
Department of Oral and Maxillofacial Surgery

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THIRD MOLAR ERUPTION PREDICTION

The diagnosis and treatment of third molars has often been cited as being a special problem to the orthodontist. The third molar teeth must be evaluated by every orthodontist in treatment planning and no orthodontic case should be considered finished until these teeth have erupted or been removed. The main areas of concern are whether the third molars will erupt or become impacted and whether the extraction of some other teeth will have an effect on the eruption of third molars and prevent crowding. Mandibular third molar impaction is a major problem in orthodontics. Its occurence ranges from 9.5%[14] to 25%.[4] Among orthodontic patients the figures are higher. Ricketts[32] said that more than 50% of orthodontic patients require the extraction of lower third molars. Richardson[29] found 35% of orthodontic patients treated without extractions had mesioangular impaction of lower third molars.

Many factors have been suspected in causing mandibular third molar impaction. It has been shown that absence from the diet of rough and coarse food is a factor in the production of maldevelopment of the dental arches. A coarse fibrous diet usually produces a greater mean arch width and iincreased wear of the occlusal surfaces of the teeth. The evidence seems conclusive that our highly refined modern diet plays a role in the etiology of malocclusions.[24] This is seen especially in the increased incidence of impacted third molars with the modern diet.

Shortage of space has long been seen as a major factor in the etiology of lower third molar impaction. Henry and Morant[15] advocated using their Third Molar Index for predicting the impaction of lower third molars. This was obtained by showing the mesiodistal width of the third molar as a percentage of the space available measured on bimolar radiographs. Impaction could be determined if this index reached a value greater than 120 for a person at maturity.

Bjork et. al.[4] established an association between impaction and lack of space for the lower third molar. They found the lack of space was correlated with three skeletal factors: vertical direction of the condylar growth, deficient growth in length of the mandible, and a distally directed eruption of the dentition. A fourth factor which contributed to third molar impaction was delayed maturation of the tooth.

Broadbent[5] felt that a third molar became impacted when the mandible failed to achieve its full optimal growth. Olive and Basford[26] found that the ratio between the inter-second molar width and the inter-ramal width, as measured from posteroanterior cephalograms, is an important factor in the identification of possible impaction of mandibular third molars.

Ricketts[32] felt his theory of arcial growth of the mandible explained how third molars became impacted. He concluded that space was made for the normally developing third molar by a forward direction of tooth eruption. He stated that if 50% of the third molar crown is ahead of the external oblique ridge at maturity, as viewed on a lateral cephalogram, there is a 50% chance of eruption.

Dierkes[6] discovered some lower third molars can become impacted even with an apparent sufficiency of space.

Schulhof[36] and others[15,21,34,39] have claimed that space is not only important but have devised plans for predicting that space.

Richardson[27] and Haavikko[13] felt space is not the only thing to consider. The angle and normal rotation of the developing lower third molar are key factors for its eruption. They found that a small degree of initial mesial angulation of the lower third molar is favorable for eruption. Such angulation is normal in all lower molars in their early developmental stages. It was felt that impaction involves insufficient uprighting of the developmentally tilted lower third molar.

It was shown by Faubion[7] that the space for eruption of mandibular third molars is increased in cases treated by extraction of premolars. Richardson[27] found that extraction of a molar almost always eliminates third molar impaction.

These findings seem to show that if space is available a third molar should erupt and that its impaction is a manifestation of a tooth/tissue disharmony or crowding.

If one could determine the prognosis of third molars more accurately as to whether they will erupt or become impacted, then orthodontic treatment could progress on a more positive basis.

The purpose of this study was to investigate factors which might help in the prediction of whether or not a developing third molar would erupt. It might be possible to use measurements of certain dimensions based on cephalometric analysis to aid in this prediction. This study was not biased in the controversy of whether third molars should be removed or not, but places emphasis on the value of evaluating the third molars during treatment planning.

METHODS AND MATERIALS

A population of 130 orthodontically treated patients was randomly selected from the files of Roger Fredsall, D.D.S., M.S.[8] Their ages ranged from 9 years 2 months to 13 years 10 months at the start of treatment. The patients were then observed for a period ranging from 6 to 10 years. During this period records were taken which included lateral cephalometric and panorex radiographs. Of the 44 males in the study 21 had four bicuspids extracted and 44 of the 86 females had four bicuspids extracted. The population did not include anyone who had any first or second molars extracted. There was also no one in the sample who had only two bicuspids extracted.

The population was divided into three groups. One group, designated the nonimpacted or erupted group, consisted of 57 patients whose mandibular third molars were fully erupted and in good occlusion by the end of the study. Another group, designated the impacted group, was made up of 36 patients whose mandibular third molars became impacted with no chance of eruption. A third group of 37 patients was in a midrange as they had not progressed far enough to determine eruption or impaction. The diagnosis of eruption or impaction was based upon clinical evaluation and studying radiographs taken during the patients' treatment. All impactions were confirmed radiographically. Of the erupted group 26 had bicuspids extracted. There were 19 extracted cases in the impacted group. In the midrange there were 19 patients who had bicuspids extracted.

There was a further catagorization of the patients based upon their facial types. They were divided into three groups as determined by analyzing the cephalometric tracings according to Ricketts' analysis (Figure 1). The first group, mesofacial, consisted of 51 patients with 23 showing favorable eruption and 15 impacted. The remaining 13 were in the unknown or midrange group. The brachyfacial group of 56 patients was divided into 24 with favorable eruption, 19 which were impacted and 13 in the midrange. In the dolichofacial group there were 23 patients with 10 having favorably erupted mandibular third molars, 2 with impactions and 11 in the midrange. This data was subjected to computer analysis to determine if there is a correlation between the eruption of third molars and facial type.

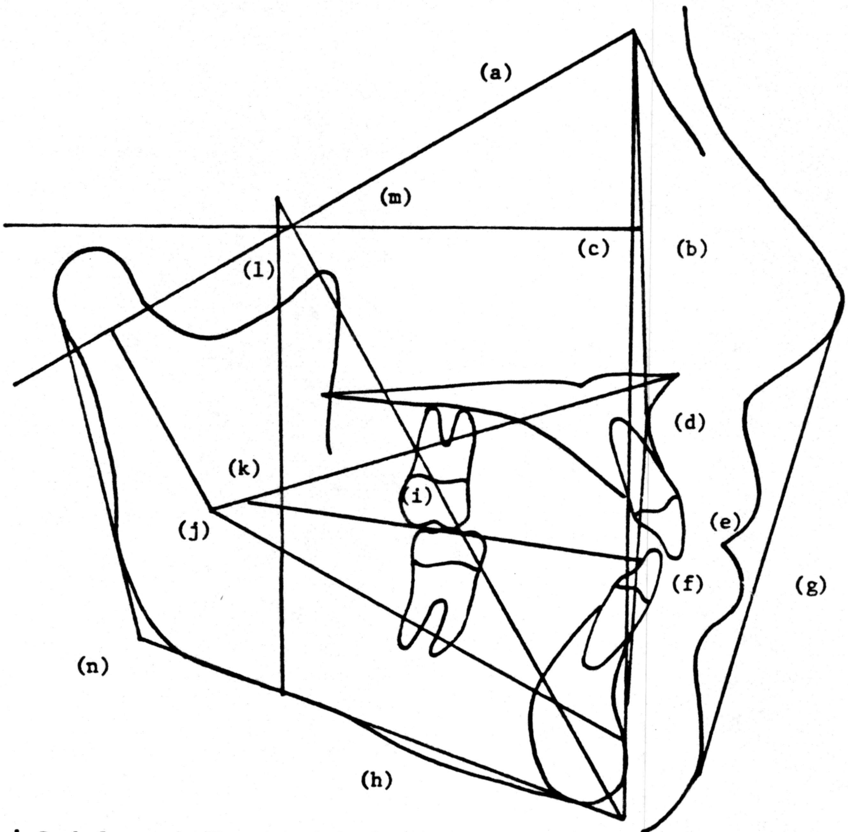
Cephalometric tracings were made at T1 using Ricketts' analysis. From the cephalometric tracings the following variables were evaluated. 1) Xi point to the distal of the mandibular second molar (for the construction of Xi point see Figure 2). 2) The angle formed by a line through the cusp tips of the mandibular third molar to the occlusal plane. 3) The distal of the mandibular second molar to

PTV. 4) The distance from the mesial of the mandibular third molar to the coronoid notch. 5) The angle formed by a line through the cusp tips of the mandibular third molar to the mandibular plane. 6) The size of the mandibular and maxillary third molar in relation to the width of the ramus. The width of the ramus was determined by measuring the most concave points of the anterior and posterior borders of the mandible. 7) The angle formed by a line through the cusp tips of the maxillary third molar to the occlusal plane. 8) The angulation of the maxillary third molar to the palatal plane. 9) The angle of the cusp tips of the maxillary third molars to PTV. 10) The distance from the distal of the maxillary third molar to PTV. 11) The distance of Xi to the distal of the maxillary second molar. 12) The distance of PTV to the distal of the maxillary first molar. 13) The distance of the mandible measured from Xi point to suprapogonion (Pm) along the corpus axis (see Figure 3). All film measurements were made twice, allowing assessment of intraexaminer reliability.

All data was subjected to a computer for mean, standard deviation, linear correlation, t-tests and discriminant analysis to ascertain if space for the lower and or upper third molar could be predicted from the lateral cephalometric radiograph.

The T1 data was divided into three groups, impacted, nonimpacted and unknown. Within each group was a further division of extracted bicuspids and non-extracted bicuspids. As suggested by Bolton the sexes were coalesced.

FIGURE 1 - Ricketts' Cephalometric Norms



Ricketts' Cephalometric Norms and Analysis for a 9 Year Old

(a)	Anterior Cranial Base	55mm ± 2.5mm	Increases .8mm/yr
(b)	Maxillary Depth	90° ± 3°	No change with age
(c)	Facial Depth	86° ± 3°	Increases 1°/3 yrs
(d)	Convexity of Point A	2mm ± 2mm	Decreases 1mm/3 yrs
(e)	Upper Incisor to APO	3.5mm ± 2.3mm	No change with age
(f)	Lower Incisor to APO	1mm ± 2mm	No change with age
(g)	Lower Lip to E Plane	-2mm ± 2mm	Less protrusive with growth
(h)	Mandibular Plane	26° ± 4.5°	Decreases 1°/3 yrs
(i)	Upper Molar to PTV	Age + 3mm ± 3mm	Increases 1mm/yr
(j)	Mandibular Arc	26° ± 4°	Increases .5°/yr
(k)	Lower Face Height	47° ± 4°	No change with age
(l)	Facial Axis	90° ± 3.5°	No change with age
(m)	Cranial Deflection	27° ± 3°	No change with age
(n)	Posterior Facial Height	55mm ± 3.3mm	Corrected for size

FIGURE 2 - Construction of Xi point (from Ricketts' article "Principle of Arcial Growth or the Mandible"[32])

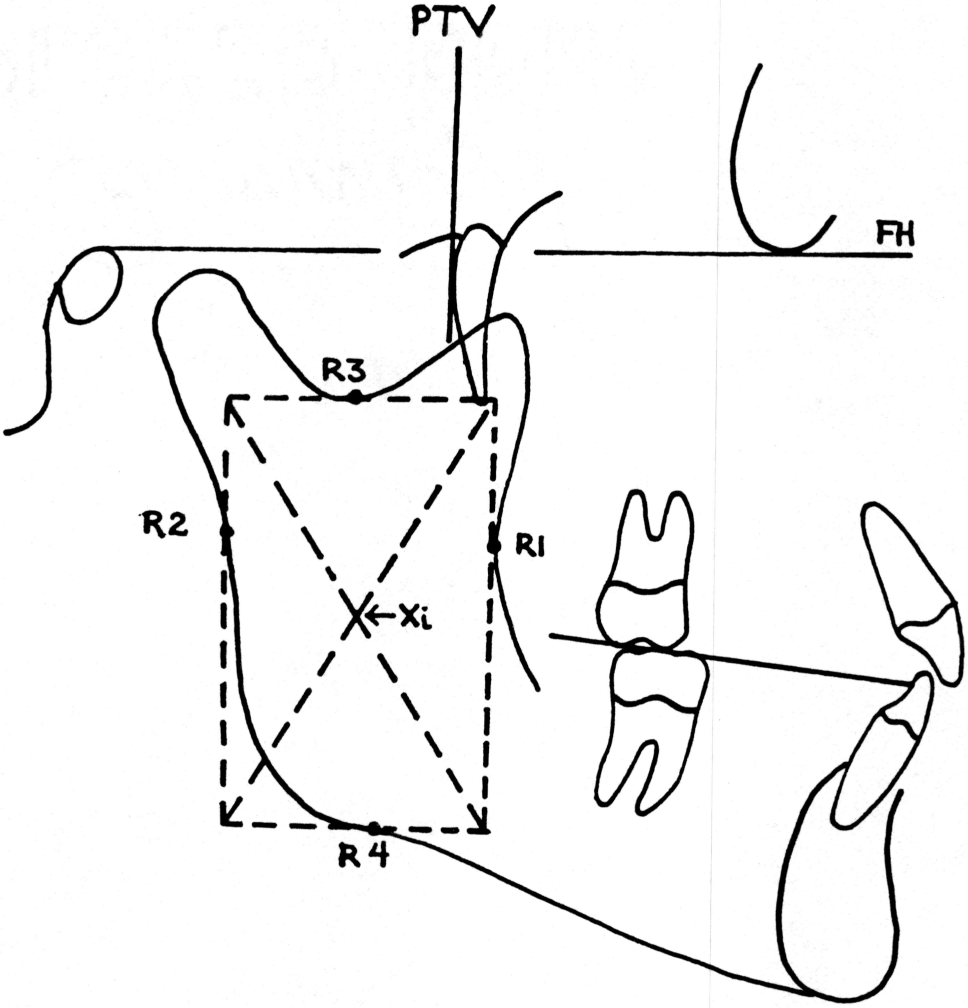
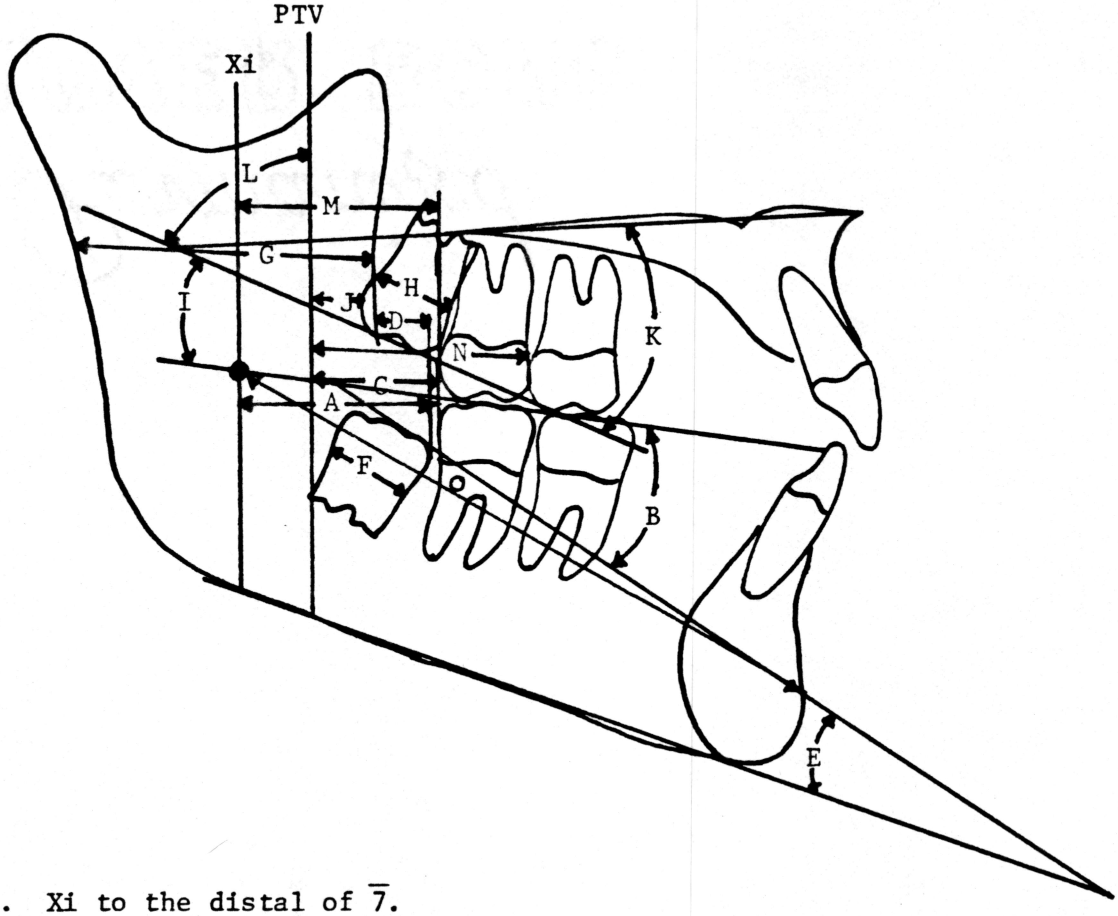
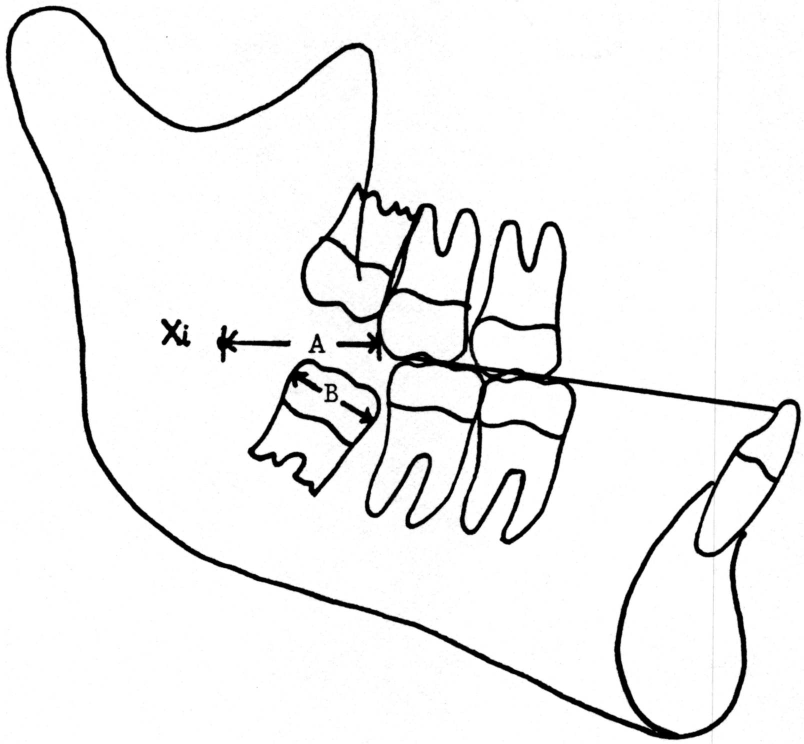


FIGURE 3 - Measurements



A. Xi to the distal of $\overline{7}$.
B. Angle of $\overline{8}$ to the occlusal plane.
C. PTV to the distal of $\overline{7}$.
D. $\overline{8}$ to coronoid notch.
E. Angle of $\overline{8}$ to the mandibular plane
F. Size of $\overline{8}$.
G. Width of ramus.
H. Size of $\underline{8}$.
I. Angle of $\overline{8}$ to the occlusal plane.
J. PTV the distal of $\underline{8}$.
K. Angle of $\underline{8}$ to the palatal plane.
L. Angle of $\underline{8}$ to PTV.
M. Xi to the distal of $\underline{7}$.
N. PTV to the distal of $\underline{6}$.
O. Xi to Pm.

FIGURE 4 - Significant measurements



A. The distance from Xi point to the distal of $\underline{7}$.

B. The size (width) of $\overline{8}$.

RESULTS

Two of the three groups (impacted and nonimpacted) were compared in regards to the mean plus or minus the standard deviation for each variable (Table I). T-tests were performed and the t-values were recorded (Table II).Discriminant analysis of the variables yielded a discriminant function expressed by the following equation:

$$1 = 2.509247 + .1964323\ (Xi\ to\ \underline{7}) - .5780075\ (8\ size)$$

where 1 is the discriminant score; Xi to 7 is the distance from Xi point to the distal of the maxillary second molar; and 8 size is the width of the mandibular third molar. The discriminant analysis was used to determine the best predictors for establishing impaction or nonimpaction. The two variables, the distance from Xi to the distal of the maxillary second molar and the size (width) of the mandibular third molar, turned out to be the most statistically significant (Figure 4). Adding other variables did not significantly increase the predictablity. From the discriminant analysis a probability equation was derived. This equation was:

$$P = \frac{1}{1 + e^{-.123 - .9746}}$$

The probability values were then calculated (Table III). It was found that if the probability value was greater than or equal to 0.5000, that individual would be classified in the erupted group; if it was less than or equal to 0.4999, the individual would be classified in the impacted group. When the discriminant scores were calculated for the subjects in the erupted and impacted groups in this study it was able to predict 75.8% of the impacted patients and 69.6% of the erupted patients. When both groups were combined the cases were correctly classified 71.9% of the time.

A discriminant analysis was also performed to determine if there was a difference in the predictablility between patients treated with extractions and those treated without extractions. In the extraction group the prediction rate was 77.8% for the impacted group and 59.3% for the erupted group. The non-extraction predictability rate was 80.0% for the impacted group and 75.9% for the erupted group. When grouped together the prediction rate for extraction cases was 66.7% and for the non-extraction cases it was 77.2%.

The third or unknown group was analyzed and its discriminant scores and probability were recorded (Table IV). From this data it was predicted whether the cases would fall into the erupted or impacted third molar group.

A Chi-squared test was used to determine if there was a correlation between facial type and the incidence of impaction or eruption. The p value of 0.27 shows there is no significance (Table V).

Finally, from a clinical standpoint, it was statistically found that if the distance from Xi point to the distal of the maxillary second molar was 21 mm or greater there was a 60% predictability that the mandibular third molar would erupt. The predictability increases with increasing distance as well as when the size of the mandibular third molar decreases.

Table I - Means ± Standard Deviations

	IMPACTED	ERUPTED	UNKNOWN	ALL
XI TO $\overline{7}$	16.9 ± 5.4	19.6 ± 5.8	16.8 ± 5.4	18.0 ± 5.7
ANGLE OF $\overline{8}$ TO OCCLUSAL PLANE	30.6 ± 11.9	33.2 ± 10.6	38.4 ± 8.6	33.7 ± 10.8
PTV TO $\overline{7}$	6.6 ± 5.2	9.4 ± 5.6	6.9 ± 5.1	7.9 ± 5.5
$\overline{8}$ TO CORONOID NOTCH	-1.9 ± 3.3	1.2 ± 2.7	-1.5 ± 2.7	-0.3 ± 3.2
ANGLE OF $\overline{8}$ TO MANDIBULAR PL.	20.6 ± 11.9	21.1 ± 9.2	22.5 ± 7.7	21.3 ± 9.6
SIZE OF $\overline{8}$	11.8 ± 1.6	11.1 ± 1.2	11.1 ± 1.2	11.3 ± 1.3
WIDTH OF RAMUS	30.5 ± 2.3	30.8 ± 2.7	30.2 ± 2.7	30.6 ± 2.6
SIZE OF $\underline{8}$	9.7 ± 1.2	9.6 ± 1.0	9.6 ± 1.0	9.6 ± 1.1
ANGLE OF $\underline{8}$ TO OCCLUSAL PLANE	30.7 ± 10.6	28.2 ± 10.1	28.0 ± 11.5	28.8 ± 10.5
PTV TO $\underline{8}$	5.7 ± 2.7	6.5 ± 2.7	5.6 ± 2.5	6.0 ± 2.7
ANGLE OF $\underline{8}$ TO PALATE	40.1 ± 10.4	38.7 ± 10.9	38.8 ± 11.1	39.1 ± 10.6
ANGLE OF $\underline{8}$ TO PTV	54.1 ± 10.5	54.8 ± 10.2	55.9 ± 10.3	54.9 ± 10.2
XI TO $\underline{7}$	18.6 ± 3.1	21.6 ± 4.8	19.6 ± 3.3	20.2 ± 4.2
PTV TO $\underline{6}$	18.3 ± 4.2	20.7 ± 5.0	18.3 ± 4.7	19.4 ± 4.9

TABLE II - Student's "t" Tests (pooled variance estimate)

	VARIABLE	T VALUE	2-TAIL PROBABILITY
1.	Xi to $\overline{7}$	-2.22	0.029
2.	Angle of $\overline{8}$ to Occlusal plane	-0.82	0.414
3.	PTV to $\overline{7}$	-2.42	0.018
4.	$\overline{8}$ to coronoid notch	-3,67	0.001
5.	Angle of $\overline{8}$ to mandibular pl.	-0.18	0.857
6.	Size of $\overline{8}$	2.56	0.012
7.	Width of ramus	-0.39	0.699
8.	Size of $\underline{8}$	0.07	0 943
9.	Angle of $\underline{8}$ to occlusal plane	0.83	0.413
10.	PTV to $\underline{8}$	-1.21	0.231
11.	Angle of $\underline{8}$ to palate	0.45	0.658
12.	Xi to $\underline{7}$	-3.26	0.002
13.	PTV to $\underline{6}$	-2.31	0.023
14.	Xi to Pm	-1.68	0.097

Table III - Probability values for each case - determined by the equation:

$$P = \frac{1}{1 + e^{-.123 - .97461}}$$

Case number	Probability	Case number	Probability
1	0.7421*	73	0.4995
5	0.7072*	75	0.3241
6	0.5023*	78	0.5776*
7	0.4350	80	0.8252*
8	0.3217	81	0.6623*
10	0.2444	82	0.5968*
14	0.6393*	84	0.7940*
16	0.3649	85	0.9298*
17	0.3217	87	0.7244*
22	0.4103	88	0.8455*
23	0.2646	89	0.5527*
24	0.5023*	90	0.3847
25	0.4103	91	0.4103
27	0.5968*	92	0.0796
28	0.6444*	94	0.4573
30	0.9620*	95	0.8483*
31	0.3193	96	0.5023*
32	0.3649	98	0.5500*
33	0.8236*	99	0.2814
36	0.2444	100	0.1823
38	0.7576*	101	0.3598
39	0.6444*	102	0.5500*
40	0.7244*	103	0.7940*
42	0.2646	105	0.3873
43	0.8483*	107	0.5023*
45	0.1282	108	0.3217
47	0.4518	109	0.4545
48	0.7590*	110	0.4076
49	0.4129	111	0.5473*
50	0.8726*	112	0.3649
51	0.4545	114	0.3217
53	0.7610*	115	0.5941*
54	0.5968*	116	0.4545
55	0.6893*	117	0.3649
56	0.5050*	119	0.1823
57	0.0485	121	0.5445*
58	0.5968*	122	0.3193
59	0.6822*	124	0.3649
60	0.3649	125	0.6893*
61	0.6368*	126	0.9232*
65	0.8483*	127	0.8511*
66	0.4129	128	0.6822*
69	0.5023*	129	0.6870*
70	0.4103	130	0.7922*
71	0.2814		

* indicates case is in the erupted group

Table IV - Prediction of unknown group 3.

Case Number	Probability Value	Predicted Group
2	0.6823	Eruption
3	0.8891	Eruption
4	0.4296	Impaction
11	0.4869	Impaction
12	0.3887	Impaction
13	0.6393	Eruption
15	0.6444	Eruption
18	0.3642	Impaction
19	0.8689	Eruption
20	0.4545	Impaction
21	0.4545	Impaction
26	0.7222	Eruption
29	0.4520	Impaction
35	0.3624	Impaction
41	0.6021	Eruption
44	0.3242	Impaction
46	0.6170	Eruption
52	0.4811	Impaction
62	0.5916	Eruption
63	0.5968	Eruption
64	0.4545	Impaction
67	0.4545	Impaction
72	0.4573	Impaction
76	0.3649	Impaction
77	0.6420	Eruption
79	0.4573	Impaction
83	0.6444	Eruption
86	0.5942	Eruption
93	0.7267	Eruption
97	0.3624	Impaction
113	0.4545	Impaction
118	0.3242	Impaction
120	0.5968	Eruption
123	0.3218	Impaction

Table V - Chi-squared test to determine if there is a correlation between facial type and incidence of eruption or impaction.

	MESOFACIAL	BRACHYFACIAL	DOLICHOFACIAL	TOTAL
IMPACTED	15	18	2	35
ERUPTED	23	25	10	58
TOTAL	38	43	12	93

$X^2 = 2.63$

df = 2

p = 0.27

DISCUSSION

For the clinician evaluating third molars, the problem has usually been a question of what factors to consider and how best to evaluate them. Most investigators feel that the major factor to access is the space available for the third molars.[4,15,21,36] Although the size of the lower third molar has not been shown to be a highly significant factor in the etiology of impaction, especially when considered alone, it has been implicated by Henry[15,16] and Richardson.[30] A major benefit of taking both factors into account simultaneously is that the effect of radiographic magnification on the interpretation of results is minimized.[25]

Ricketts and associates[33] established the use of Xi point as a reference point in establishing space available for the eruption of lower third molars. Olive and Basford[25] found a strong positive correlation ($r = 0.76$) between the dimension from Xi point to the lower second molar and the space width ratio derived from direct measurements. They concluded, though, that prediction of impaction or eruption based on Xi point to the lower second molar is not sufficiently reliable. They felt further information was needed if Xi point were to be used. From the data presented in this study it is felt there is sufficient evidence to use Xi point as a reference.

The evidence presented here seems to establish the distance from Xi to the distal of the maxillary second molar and the width of the mandibular third molar as significant variables related to impaction. It was found that the addition of other variables does not significantly increase the reliability of prediction. It should also be mentioned that there was no attempt made to adjust the distance from Xi to the distal of the maxillary second molar due to changing age. If the normal increase with age was considered there might have been an increase in the rate of predictability.

It should be pointed out that because Xi point is measured from the anterior border of the mandible, the findings of Ricketts' arcial growth and this study coincide well.

Using the discriminant analysis it was found that the prediction rate for the impaction group was 75.8%. The prediction rate of the erupted group was 69.6%. This shows there is a high degree of success in being able to predict the prognosis of third molars. When further divided into groups of extraction and non-extraction the prediction rate was still high, being accurate 66.7% for extraction cases and 77.2% for non-extraction cases.

This study also used the discriminant scores and probablities of the third, unknown, group to predict the final prognosis of third molars in these cases. Further follow-up will be necessary to determine the accuracy of these results. There should be an overall prediction rate of 71.9% This study should also be subject to further investigation by using a new patient pool. The new patients should be analyzed using the same discriminant analysis equation to determine the accuracy of this study in predicting the fate of third molars.

Since sixteen t-tests were performed the maximum p-value for significance was determined by dividing the level of significance (.05) by the number of variables (16). This resulted in a maximum p-value of significance equal to .003. Therefore, this means that only two variables, the mesial of the mandibular third molar to the coronoid notch and Xi point to the distal of the maxillary second molar, can be considered significant according to the t-test.

It should be mentioned that on the Chi-squared analysis assessing the correlation between facial type and the incidence of impaction or eruption that the size of the dolichofacial patients is very small. A larger sample size of dolichofacial patients may or may not have had a different effect on this study's outcome.

When accessing the predictability of third molars one must take into account that third molars are the teeth that are most often congenitally missing. Estimates of the percentage of persons with one or more third molar missing range from 9% to 20%.[3] According to Richardson,[29] there are more females than males with congenital absence of third molars; a 3:2 ratio exists. The congenital absence of third molars must therefore be considered when looking at establishing their predictablilty.

The third molar may be a particular problem to the orthodontist attempting to correct a malocclusion. However, in the act of making space for the lower incisors or anchorage preparation, the distal movement of the first molars may be required. This may result in limited space for the second molar with impaction of the third molar.[33] This can be especially true using the Bioprogressive technique. In situations such as this it would appear enucleation at an early age may be benificial.

It should also be pointed out that this study was not designed to show the effects of orthodontic treatment and this has undoubtedly introduced error. To correct this, if further study were undertaken, it would be helpful if an equal number of untreated cases with parallel records was used. In this way their lower third molar space and fate could be compared with the test sample.

SUMMARY

Nothing biological can be predicted with absolute certainty. This study, however, was able to show there was a high degree of success in being able to predict the fate of third molars. It shows there is an accurate means of predicting third molar impaction from radiographic measurements.

This study showed the distance from Xi point to the distal of the maxillary second molar is a significant factor in the impaction of third molars. The size of the lower third molar when combined with the distance of Xi to the distal of the maxillary second molar is a significant contributing factor in accessing the fate of third molars.

The discriminant analysis was able to satisfactorily predict 75.8% of the impacted group and 69.6% of the erupted group in the population studied.

This study shows that the removal of first or second bicuspids had only a small effect on the predictability of third molars in this population. This is shown by an overall prediction rate of 66.7% of the extraction cases and 77.2% of the non-extraction cases.

It was also found by using a Chi-Squared test that there was no correlation between facial type and the incidence of impaction or eruption of third molars.

From a clinical standpoint it was found that if the distance from Xi point to the distal of the maxillary second molar was 21 mm or greater there was a 60% predictability that the third molars would erupt. The predictability increases with increasing distance as well as when the size of the mandibular third molar decreases.

Although averages in a study of this kind are permitted only to show tendencies and trends, these averages might still be applied to the individual patient, and give the orthodontist a more definite idea as to the final fate of third molars.

In this paper an attempt was made to devise a simplfied method of predicting space for the third molars. The method described should be used only as a guide in deciding the fate of third molars. Proper diagnostic procedures should still be followed. This should include a long range growth forcast, such as Ricketts' arcial method. If the practitioner is not skilled in manual methods of long range growth analysis a commercial forcasting service such as Rocky Mountain Data Systems[35] is a viable alternative.[23]

Further study and consideration should be undertaken to access the findings presented in this study.

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