The Etiology and Prediction of Mandibular Third Molar Impaction

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Mandibular third molar impaction is a major problem in modern dentistry. Figures ranging from 9.5%[7] to 25%[2] have been quoted for its occurrence in different populations. Among orthodontic patients the figures are higher. Ricketts[14] claimed that more than 50% of orthodontic patients require extraction of lower third molars. Richardson[13] found that 35% of orthodontic patients treated without extractions had mesioangular impaction of lower third molars, and a further 20% had vertical impactions or associated problems.

Although many impacted teeth may remain symptom free throughout life, they are a potential source of trouble and their early removal is generally recommended. The orthodontist is constantly aware of the developing third molar and its possible effect on the dentition during and after orthodontic treatment. The effect of orthodontic treatment on developing third molars should also be considered and measures to relieve developing impactions included in the treatment plan. It is not always easy, however, to achieve this end since the etiology of third molar impaction has not been fully explained.

There is a general consensus that the main factor is shortage of space. The way in which this shortage arises has been explained in a variety of ways.

Broadbent[3] believed that when a third molar became impacted the mandible had failed to achieve its full growth potential.

Begg[1] claimed that there was insufficient forward movement of the dentition of modern man due to lack of attrition resulting in lack of space for the third molar.

Björk[2] showed that third molar impaction was associated not only with a reduced amount of growth, but also with a more downward as opposed to forward growth direction. He found that backward direction of eruption and retarded maturation were associated factors.

Ricketts[14] considered that his theory of arcial growth of the mandible explained how third molars became impacted. He believed that space was made for the normally developing third molar by a forward direction of tooth eruption rather than resorption at the anterior border of the ramus. This supports Björk's observation of a distal direction of eruption in association with lack of space for the third molar.

Faubion[4] has shown that the prevalence of third molar impaction is reduced, but not eliminated, in cases treated by extraction of premolars. Richardson[10] found that extraction of a molar almost eliminates the occurrence of third molar impaction.

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

It should therefore be possible to demonstrate differences in the relative size and shape of the mandible and teeth between subjects with impacted third molars and those with erupted third molars. It might also be possible to predict, from the measurement of certain dimensions, whether or not a developing third molar will erupt.

It was decided to test these hypotheses using the material collected in a longitudinal study of third molar development.

TABLE I

Details of the impacted third molar group (1) and the erupted third molar group (2).

Impacted Group	No.	No. of $\overline{8}$ Left	No. of $\overline{8}$ Right	No. of $\overline{8}$ Left	No. of $\overline{8}$ Right
Female	27	27	25	23	21
Male	18	18	18	12	15
Total	45	45	43	35	36
Erupted Group					
Female	27	27	27	—	—
Male	23	23	22	—	—
Total	50	50	49	—	—

MATERIAL

The material consisted of a group of 45 subjects with one or two impacted mandibular third molars and a group of 50 subjects whose lower third molars had erupted (Table I). Both groups formed part of a longitudinal study of third molar development on patients referred for orthodontic treatment. They have been recorded, at yearly intervals, from the age of 10 to 11 years until their third molars had erupted or were diagnosed as impacted. The observation period ranged from 7-10 years. Impaction was diagnosed at age 18 years or more, when the third molar had remained in the same relative position for at least 3 years, and was prevented from eruption because of its mesioangular relationship with the second molar. Vertical impactions were excluded because of difficulties in diagnosis.

Annual recordings included a set of plaster models, and cephalometric radiographs taken in the 90° left lateral, 60° left and right lateral, and straight P.A. positions.[10]

On the final set of 90° lateral cephalometric radiographs the following dimensions were measured: A) SNA-SNB difference, B) articulare to pogonion, C) gonion to pogonion, D) the gonial angle, and E) growth of the mandible by the increase in length from articulare to pogonion between first and last films.

On the final set of posteroanterior radiographs, F) the width of the mandible was measured at the widest point of the mandible in the region of gonion.

On the first set of 60° rotated cephalometric radiographs were noted: G) the size of the lower third molar, i.e., the maximum mesiodistal width of the tooth, H) the space between the developing lower second and third molars measured as the shortest distance between the distal surface of the second molar and mesial surface of the third molar, I) the angulation of the lower third molar to the mandibular plane, measured as the angle between a line through the occlusal surface of the third molar and a line joining gonion and menton, J) the stage of development using the same system as Björk which was based on a classification described by Gleiser and Hunt[6] for the mandibular first molar: (1) no calcification, (2) calcification of cusps only, (3) calcification of half crown, (4) calcification of whole crown and (5) root formation started.

On the first set of plaster models with a complete permanent dentition anterior to the first permanent molar, K) the space condition was measured as arch length minus total tooth size.[10]

The reproducibility of the radiographic measurements has been described previously.[10]

RESULTS

Comparisons were made between the impacted third molar group (1) and the erupted third molar group (2) in respect of the variables A to I, using Students 't' test. Right and left sides were tested separately where appropriate. Figures are quoted for all the subjects together as well as for males and females separately (Tables II, III and IV).

When all subjects were considered

TABLE II

Showing the differences between the impacted third molar group (1), and the erupted third molar group (2) for measurements made on the *final* set of 90° left lateral, and straight posteroanterior radiographs.

Variable		Group (1) mean	Group (2) mean	Diff. Between means 1-2	Degrees of freedom $n_1 + n_2 - 2$	t
A SNA-SNB	All Cases	4.38°	2.21°	2.17°***	93	3.77
	Female	4.65	3.19	1.46*	52	2.12
	Male	3.97	1.09	2.88**	39	3.10
B Ar/Pog	All Cases	113.87 mm	117.54	—3.67*	93	2.27
	Female	109.15	112.48	—3.33*	52	2.58
	Male	120.94	123.48	—2.54	39	1.32
C Go/Pog.	All Cases	77.27 mm	79.86	—2.59*	93	2.32
	Female	74.65	77.0	—2.35*	52	2.24
	Male	81.20	83.24	—2.04	39	1.54
D Gonial Angle	All Cases	115.10°	118.92°	—3.82°*	93	2.42
	Female	114.98	118.43	—3.45	52	1.73
	Male	115.31	119.50	—4.19	39	1.58
E Growth of Mandible	All Cases	11.20 mm	14.72	—3.52**	93	3.39
	Female	8.72	11.69	—2.97**	52	3.26
	Male	14.92	18.28	—3.36*	39	2.32
F Width	All Cases	101.94 mm	103.95	—2.01	93	1.34
	Female	99.32	99.69	—0.37	52	0.22
	Male	105.90	109.00	—3.10	39	1.57

(*** denotes significance at 0.1 per cent level, ** at 1.0 per cent level, * at 5.0 per cent level, in Tables II, III, IV, VI and VII).

TABLE III

Showing the differences between the impacted third molar group (1) and the erupted third molar group (2) for measurements made on the first set of 60° left lateral radiographs.

Variable		Group (1) mean	Group (2) mean	Diff. Between means 1-2	Degrees of freedom $(n_1 + n_2 - 2)$	t
G Size $\overline{8}$	All Cases	11.73	11.56	0.17	83	0.82
	Female	11.39	11.24	0.15	48	0.58
	Male	12.38	11.93	0.45	33	1.50
H Space $\overline{7}$ and $\overline{8}$	All Cases	1.70	0.93	0.77**	83	3.26
	Female	1.93	1.09	0.84*	48	2.63
	Male	1.25	0.74	0.51	33	1.46
I $\overline{8}$/M.P.	All Cases	44.87°	34.91°	9.96°**	83	3.60
	Female	47.15	34.33	12.82***	48	3.93
	Male	40.50	36.20	4.30	33	0.93

together, significant (at $P < 0.05$, used throughout) average differences between the two groups were found for skeletal pattern, as measured by the SNA-SNB difference, and for the size and shape of the mandible measured by articulare/pogonion, gonion/pogonion and gonial angle. Division of the subjects into male and female subgroups produced a similar pattern of differences, although not all reached the level of statistical significance.

There was a significant average difference in amount of growth of the mandible between impacted and erupted groups.

The average difference in width of the mandible was not significant. It was, however, larger and more nearly significant for males than females.

Average differences in size of the third molar were small and nonsignifi-

TABLE IV

Showing the differences between the impacted third molar group (1) and the erupted third molar group (2) for measurements made on the first set of 60° right cephalometric radiographs.

Variable		Group (1) mean	Group (2) mean	Diff. Between means 1-2	Degrees of freedom $(n_1 + n_2 - 2)$	t
G Size $\overline{8}$	All Cases	12.04 mm	11.65	0.39	83	1.97
	Female	11.62	11.57	0.05	46	0.21
	Male	12.63	11.84	0.79*	35	2.55
H Space $\overline{7}$-$\overline{8}$	All Cases	2.00 mm	1.11	0.89**	83	3.22
	Female	2.36	1.22	1.14**	46	2.78
	Male	1.53	0.98	0.55	35	1.38
I 8/M.P.	All Cases	41.40°	36.52°	4.89°*	83	2.00
	Female	39.76	35.91	3.85	46	1.20
	Male	43.70	36.71	6.99	35	1.80

cant except for the subgroup males on the right side.

Significant average differences in the space between the developing second and third molars were found, on both sides, for all the subjects and in the female subgroup.

Significant average differences were found between the two groups for the initial angulation of the third molar to the mandibular plane for all subjects and for the female subgroup on the left side.

The stage of development of the lower third molar at the beginning of the investigation was compared in the two groups using a Chi-squared test. This showed that the third molars in the erupted group were at a significantly later stage of development than the impacted group. The actual values of χ^2 were 13.2 for the left side and 17.7 for the right side. Both results are significant ($P < 0.001$). The distribution of the stage of development is shown in Table V.

In view of these results it was decided to determine if the variables could be used to predict accurately the impaction or eruption of developing third molars. For such an approach to be of practical value, discrimination must be made using *initial* values of the measurements concerned before clinical classification into impacted or erupted groups can be made. The variables A, B and D were therefore remeasured on the *first* set of radiographs (A_1, B_1 and D_1); the results are shown in Table VI.

The average differences between the groups were all smaller than before and nonsignificant with the exception of length of the mandible (Ar-Pog) for the group as a whole.

Average differences in initial space condition between the two groups were tested and the results shown on Table VII. No significant differences were found.

A linear discriminant function was derived,[5] using the variables A_1, B_1, D_1,

TABLE V

Showing the distribution of stages of lower third molar development in impacted and erupted groups.

GROUP		Stage of Development 1	2	3	4	5	Total
Impacted	Left	0	27	5	3	0	35
	Right	5	25	5	1	0	36
Erupted	Left	0	19	24	6	1	50
	Right	0	20	23	5	1	49

Stage 1 No calcification
" 2 Calcification of cusps only
" 3 Calcification of half crown
" 4 Calcification of whole crown
" 5 Root formation started.

TABLE VI

Showing the differences between the impacted third molar group (1) and the erupted third molar group (2) for measurement made on the *first* set of 90° left lateral radiographs.

Variable		Group (1) mean	Group (2) mean	Diff. Between means 1-2	Degrees of freedom $(n_1 + n_2 - 2)$	t
A_1 SNA-SNB	All Cases	4.84°	4.06°	0.78°	93	1.50
	Female	4.74°	4.44°	0.30°	52	0.46
	Male	5.00°	3.61°	1.39°	39	1.64
B_1 Ar/Pog	All Cases	101.19 mm	103.56	—2.37*	93	2.39
	Female	99.72	101.59	—1.87	52	1.63
	Male	103.39	105.87	—2.48	39	1.72
D_1 Gonial Angle	All Cases	119.69°	121.85°	—2.16°	93	1.46
	Female	119.22°	120.76°	—1.54	52	0.76
	Male	120.39°	123.13°	—2.74°	39	1.31

TABLE VII

Showing the differences between the impacted third molar group (1) and the erupted third molar group (2) for space condition (arch length — total tooth size) measured on the first set of plaster models with a complete permanent dentition anterior to the first molar.

		Group (1) mean	Group (2) mean	Diff. Between means 1-2	Degrees of freedom $(n_1 + n_2 - 2)$	t
Left	All Cases	—1.43	—2.25	0.82	83	1.78
	Female	—1.67	—2.30	0.63	48	1.11
	Male	—0.98	—2.20	1.22	33	1.94
Right	All Cases	—1.68	—2.05	0.37	83	0.77
	Female	—1.75	—1.62	—0.13	46	0.24
	Male	—1.59	—2.58	0.99	35	1.43

TABLE VIII

Misclassification Table

Left

Discriminant Classification	Actual Groups Impacted	Erupted
Impacted	22	9 (18.0%)
Erupted	13 (37.1%)	41
Total	35	50

Total misclassification rate = 22/85, 25.9%

Right

Discriminant Classification	Actual Groups Impacted	Erupted
Impacted	23	6 (12.2%)
Erupted	13 (36.1%)	43
Total	36	49

Total misclassification rate — 19/85, 22.4%

G, H, I and K as independent variables, to determine if future impaction or eruption could be accurately predicted. Each side of the mandible was analysed separately. Using this discriminant function, a subject was assigned either to the erupted or the impacted group. Comparison of the discriminant classification with the actual grouping (Table VIII) showed that membership of the erupted group could be more accurately predicted than membership of the impacted group (misclassification rate: erupted, left 18.0% right 12.2; impacted, left 37.1% right 36.1).

Discussion

These results showed that subjects who have impacted third molars differed in a number of ways from those whose third molars erupt.

There was a higher proportion of

subjects with a skeletal Class II dental base relationship among those with impacted third molars compared with the erupted third molar group. This became more obvious with age. The difference at the end of the investigation was statistically significant while at the beginning it was not.

The mandible was shown to be shorter in the impacted group than in the erupted group, both in terms of over-all length (articulare/pogonion) at the beginning and end of the investigation, and in body length (gonion/pogonion) at the end. Kaplan[9] claimed that cases with impacted third molars did not exhibit shorter mandibular lengths than cases with erupted third molars. However, his figures showed a shorter mandibular length in the impacted group compared with the erupted group in females. Although in Kaplan's material this difference was not statistically significant, it shows the same trend as the present findings where the reduction in length of the mandible in impacted cases was more obvious in females than in males.

Differences were found between the impacted and erupted groups for the shape of the mandible as measured by the gonial angle. They suggested that a smaller, more acute gonial angle was more common among those with impacted third molars. This trend was observed both at the beginning and end of the investigation for all the subjects and the sex subgroups but the difference only became statistically significant for the group as a whole at the end of the observation period. Björk used a different method of measuring mandibular shape, but the present evidence agrees with his finding that a pronounced "bend of the mandibular base" which he found as a result of a more vertical, as opposed to sagittal, direction of condylar growth was associated with third molar impaction.

The mandible grew significantly less in the impacted third molar group throughout the observation period. This, in conjunction with the difference in mandibular length, supports Björk's conclusion that a reduced amount of mandibular growth, resulting in a reduction in length of the mandible, are among the factors contributing to insufficient space for the developing third molar to erupt.

It is clear that very little importance can be attached to differences in width of the mandible. They do, however, contribute to the general picture of a slight over-all reduction in size of the mandible in impacted third molar cases.

Although differences in third molar size were small and mostly nonsignificant, they showed a tendency for the third molars to be slightly larger in the impacted group. This is in agreement with Henry's suggestion that a small third molar is less likely to become impacted than a larger one.[8]

The significantly larger space between the developing second and third molars in the impacted group is contrary to what might be expected. This early spacing, observed in 82% of cases, appears to close quite rapidly.[10] The erupted third molar group was at a slightly later stage of development at the beginning of the investigation, as shown by the Chi-squared test, and this might explain the difference in spacing between the two groups. Nevertheless, the fact that this initial spacing existed in the impacted group is contrary to Henry's theory that the presence of such spacing is indicative of normal eruption of the third molar.

The difference between the two groups for the initial angulation of the lower third molar to the mandibular plane is to be expected. It seems reasonable that a very steeply angled third molar, which will have farther to travel to erupt, is less likely to do so, especially if there is any reduction in available space. Björk was unable to demonstrate any difference in angulation of the third molars between his impacted third molar cases and the remainder of his material. His measurements were made on 90° lateral radiographs which can not distinguish between left and right sides. Quite large differences between sides were found to occur in the present material.

Differences in space condition between the two groups were small and nonsignificant. There was a slight tendency for the erupted group to exhibit more crowding than the impacted group except for the female subgroup on the right side.

It should be pointed out that an important difference between the two groups was in respect of extraction of teeth. In the impacted group 54% of subjects had an intact lower arch compared with 12% in the erupted group. The remainder in both groups had unilateral or bilateral extraction of a tooth from the lower arch. The presence of slightly more crowding in the erupted group was probably an indication for extraction therapy which in turn increased the chances of third molar eruption.

It is, of course, possible that some of the erupted third molars, in the absence of extraction, might have become impacted. However, since the direction of the differences between the variables was, for the most part, consistent with expected differences, it is suggested that any misclassifications due to extraction of teeth would be unlikely to reduce the value of the differences.

The results of the discriminant function analysis suggested that it is not possible to predict third molar impaction from measurements at the age of 10 to 11 years with any degree of accuracy. A misclassification rate of around 25% is too high to be of much clinical value. Differences in size and shape of the mandible between impacted and erupted groups are small at this age, but tend to become more obvious in later years, probably as a result of differences in degree and direction of growth. Schulhof has claimed that computerised growth prediction methods are capable of predicting the space available for the third molar.[15]

Even if such accurate estimates of mandibular growth and third molar space were available, it is doubtful if much increase in accuracy of prediction of third molar impaction would be achieved in view of the variation in behaviour of the individual third molar.

It has been shown[13] that a lower third molar may become impacted in three different ways: 1) It can follow the pattern of a normally developing third molar by decreasing its angulation to the mandibular plane and becoming more upright, but the uprighting may not be sufficient to permit eruption; 2) its angular developmental position relative to the mandibular plane may remain unchanged; and 3) it can increase its angulation to the mandibular plane and become more mesially inclined.

The last two methods of impaction constitute an atypical behaviour pattern which obviously could not be predicted from measurement of any of the variables considered in this paper. Nor could such impactions be predicted from estimates of available third molar space which must assume that the third molar will upright into such space.

Fifty-four per cent of third molar impactions in this material developed in an atypical manner. It seems unlikely, therefore, that the accuracy of prediction of third molar impaction can be improved until the rationale behind atypical angular changes in third molar behaviour is elucidated by further research.

Conclusions

1. Skeletal Class II dental base relationship with a shorter, narrower, more acute angled mandible was found in association with impacted third molars, compared with erupted teeth.

2. These differences were found at age 18+ years but were less obvious at age 10 to 11 years.

3. There was a reduced amount of mandibular growth in impacted third molar cases.

4. There was a slight tendency for impacted third molars to be larger than those which erupted.

5. The presence of a space between second and third molars in the early stages of development is not an indication that the third molar will erupt.

6. The developmental angulation of the third molar to the mandibular plane was higher in the impacted third molar group.

7. Accurate prediction of third molar impaction from radiographic measurements is not possible at age 10 to 11 years.

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