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MANDIBULAR GROWTH AND THIRD MOLAR IMPACTION

by

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MOGENS PALLING

Incomplete eruption of the mandibular third molar is one of the major problems in dentistry because of its frequent occurrence and its clinical implications.

Failure of the wisdom tooth in the lower jaw to erupt completely is usually associated with lack of space in the alveolar arch, between the second molar and the ascending ramus. Insufficient space, therefore, has been considered the main cause of impaction. This concept has been confirmed through biometrical studies by *Henry & Morant* (1936), and it is also corroborated in the present study. The causes of space insufficiency in the mandibular third molar region, however, have not been analysed though the value of cephalometrical growth studies for this purpose has been pointed out by *Broadbent* (1943).

The purpose of the present study is to determine the essential factors in mandibular growth which concern the third molar space. Three such factors were defined and their clinical application seems to be of prognostic value.

Causes of incomplete eruption apart from mandibular growth were also examined. Retarded maturation of the dentition appears to be a fourth factor to consider in the prognostication.

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Racial variations related to mandibular third molar impaction are beyond the scope of this work. Their existence has been proved and thoroughly discussed by *Pedersen* (1941, 1949), and others.

Part I

METHOD OF ANALYSIS

Third molar impaction.

The position of the third molar has been evaluated from cephalometric profile x-ray films as well as from intraoral exposures.

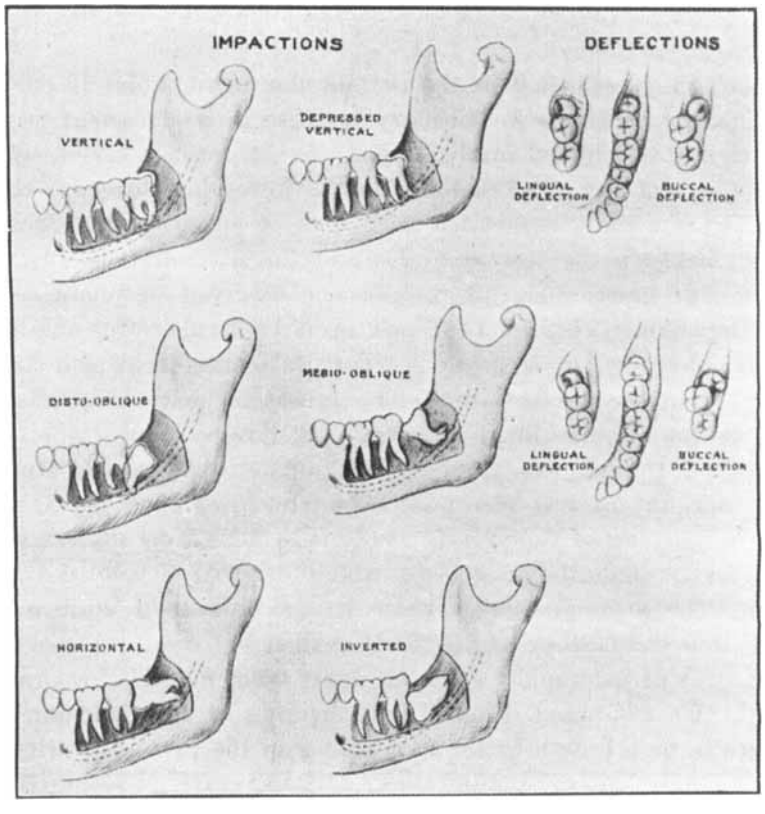


Fig. 1. Types of impaction of the lower third molars.
(Reproduced from C. B. Henry and G. M. Morant, Biometrika 1936, by kind permission.)

Incomplete eruption of the mandibular third molar is generally defined in regard to divergencies in three planes, *Winter* (1926), *Henry & Morant* (1936). The classification by the latter authors is reproduced in Fig. 1.

The horizontal and angular impactions are defined by the inclined position of the third molar against the second molar, whereby eruption is impeded (mesio-oblique, horizontal, and inverted positions), or against the ascending ramus (disto-oblique position). These four subtypes have been selected in this investigation as representative of third molar impaction, the great majority of cases displaying the mesio-oblique position. The transversal divergencies, deflections, are included provided they are associated with horizontal or angular impactions. As in young adults the vertical impactions are difficult to distinguish from conditions of retarded eruption, they have not been included.

Third molar space.

An accurate registration of the third molar space (M_3-space) in the lower jaw is not possible from lateral x-ray films. *Henry & Morant* (1936) defined the M_3-space as the distance between the second molar and the anterior edge of the ramus, on a level with the alveolar border, measured on intraoral films. A similar definition was applied by *Ledyard* (1953). In the present study the M_3-space was measured on cephalometric profile x-ray films as the distance between the distal surface of the second molar and the anterior edge of the ramus, on a level with the occlusal line of the mandibular dental arch. The occlusal line was defined as a line through the incisal edge of the lower central incisors and the center of the occlusal surface of the second molar, Fig. 2. This method aims at eliminating the influence of any mesio- or disto-angular position of the second molar. In case of double projection the midpoint was used. Cases with considerable dissimilarity between right and left sides were left out as well as cases in which the anterior contour of the ramus was not easily discernible on the x-ray film. The profile roentgenograms used for measurements were open-mouth exposures.

The above definition is open to the objection that the posterior

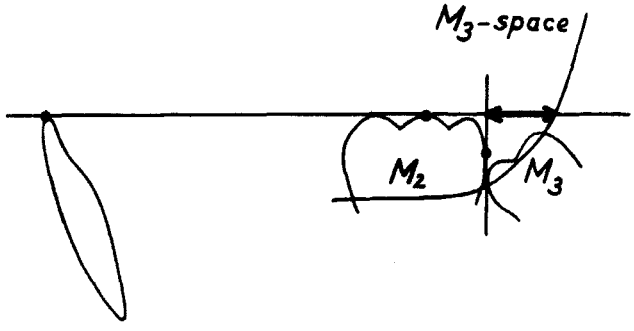


Fig. 2. Determination of third molar space (M_3-space) from cephalometric profile x-ray films.

part of the third molar region, medial to the ramus contour, has not been considered. It may further be objected that variations of the vertical position of incisors and second molars affect the level of the occlusal line and thus influences the registration of the M_3-space.

Growth of the mandible.

The growth of the mandible was estimated from cephalometric profile x-ray films, and three factors of variation in development of size and shape were related to the third molar space: —

1. *Growth in length;* Fig. 3. Insufficient increase in length of the mandible in proportion to amount of tooth substance is

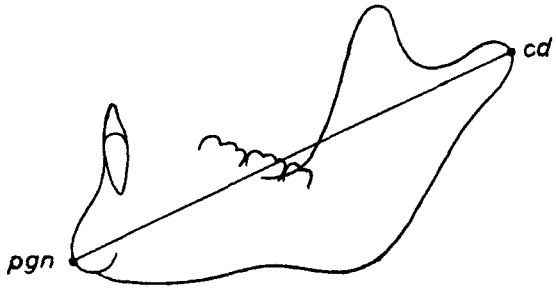


Fig. 3. Measurement of development in size of the mandible (mandibular base length).

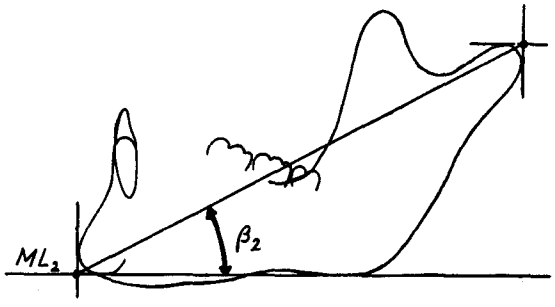


Fig. 4. Measurement of development in shape of the mandible (mandibular base angle).

generally considered to be a cause of insufficient space for the third molar. For this reason, the growth in length of the mandible is the first of the mandibular growth factors concerning third molar impaction to be considered here.

An expression of the mandibular growth in length can be found in the distance from the mental protuberance to the condyle, pgn-cd, Fig. 3 (cf. *Lindegård* 1953). This measurement is comparatively unobjectionable as the length increment is known to take place at the condyle, and apposition or resorption of greater importance does not seem to occur in the chin region (*Björk* 1955). In other words, the increase in total length of the mandible is a direct expression of the amount of condylar growth.

2. *Condylar growth direction;* Fig. 4. Apart from growth in length of the mandible, changes in shape during development may exert considerable influence on the third molar space. This was suggested from implant studies of mandibular growth (*Björk* 1955) as a vertical direction of condylar growth was found to be associated with insignificant resorption at the anterior ramus border, compared to cases with a more horizontal direction of condylar growth. Therefore, in dealing with developmental problems related to third molar impaction the second factor which concerns mandibular growth is the direction of condylar growth.

The direction of condylar growth may be evaluated by changes in the mandibular base angle during development, the β angle

(*Lindegård* 1953). This angle, however, must be regarded as a comparatively rough estimate of the direction of growth. Changes in this angle during development do occur partly because of the variations in condylar growth in the sagittal or vertical directions, i.e. the factor to be evaluated, partly because of the fact that the reference line along the lower border of the mandible is altered in consequence of appositional or resorptive growth processes (*Björk* 1955). Such modeling processes at the lower mandibular border will highly affect the estimation of the direction of condylar growth.

Until more is known about the modeling rebuilding at the lower mandibular border the choice of reference line along this border must be more or less arbitrary. Two such possibilities have been investigated in this study: The mandibular line defined as the tangent to the lower mandibular border (ML_1) (*Björk* 1947) and as the line drawn through the lowest point at the symphysis, touching the mandibular border at the angle region (ML_2). The mandibular base angles registered from these lines have been termed β_1 and β_2. The correlation analysis in this study roughly suggests the same validity of these two angles to express the direction of condylar growth. In accordance with the definition of alveolar prognathy given in the following section, however, the angle β_2 was preferred in this study, Fig. 4.

3. *Directional trend of tooth eruption;* Fig. 5. The third developmental factor to be considered in relation to the formation of the M_3-space is the directional trend of tooth eruption. Also the direction of tooth eruption was perceived from the implant studies of mandibular development (*Björk* 1955) as a factor concerning the causal relations of third molar impaction. Apparently, there are considerable individual variations in direction of eruption. Consequently, the mandibular dentition, more or less in toto, will be carried forward or backward in relation to the basal structures of the mandible in the course of development. A backward directed trend of eruption will diminish the length of the alveolar arch, thereby causing a decrease in space for the third molar. An accurate registration of the directional trend of eruption of the dentition is not possible by means of the conventional x-ray method applied here. As a suitable mea-

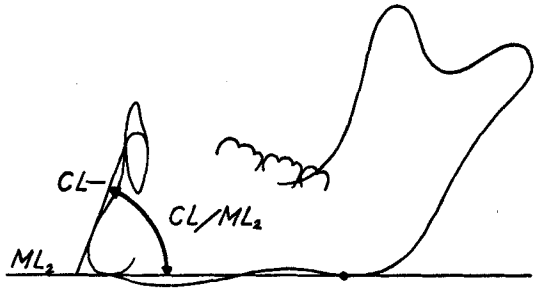


Fig. 5. Measurement of alveolar prognathy in the mandible.

surement the degree of alveolar prognathy was chosen, registered as the angle CL/ML (*Björk* 1947), i.e. the angle between the profile line of the bony chin and the mandibular line discussed above. As the increase in growth at the chin point is negligible (*Björk* 1955) a change in the alveolar profile angle during development will supply an expression of the shifting of the dentition in a retrognathous or prognathous direction in relation to the mandibular base. The degree of alveolar prognathy can therefore be used as an indirect estimation of the direction of eruption.

The same objections may be raised as in the discussion regarding the evaluation of the direction of condylar growth. Modeling rebuilding at the lower mandibular border — indispensable as a reference line — will influence the measurements. Correlations have been calculated using ML_1, respectively ML_2, as the base line. As higher values appeared for ML_2 the alveolar prognathy was computed from the angle CL/ML_2, Fig. 5. However, the degree of alveolar prognathy may not without reservation be considered as an expression of the directional trend of eruption in the dentition as a whole. Differences in direction of eruption between anterior and posterior teeth are known to occur, manifested by changes in the shape of the dental arch and by the degree of crowding, and especially pronounced in connection with loss of teeth. The application of the alveolar prognathy as an expression of the direction of tooth eruption should be regarded as an indirect method of evaluation with limited reliability. The method, however, provides a reading of the sagittal position of the alveolar arch in relation to the basal structure and thus is justified.

Part II

ADOLESCENT GROWTH STUDY GROUP

MATERIAL

The material of this section consists of cephalometric profile x-ray films of Swedish males, examined at the age of 12 and 20. The puberal growth maximum for body length is at about the age of 14 for boys (*Meredith* 1935, *Tanner* 1955). According to *Nanda* (1955) the maximum in puberal growth for the facial dimensions is retarded from a general point of view compared to the maximum for body length. The present longitudinal study thus includes the period of the puberal growth spurt of the mandible.

The material, comprising 243 individuals, has been collected to serve as a representative group, irrespective of dental conditions (*Björk* 1947, 1953). Therefore, cases with extractions or congenital absence of teeth are included. X-ray control at both age stages, cephalometric and intraoral exposures, makes it possible to evaluate the third molar development accurately.

Table I

Development of third molars in the Swedish growth study group.
(Number of M_{3}s.)

	Upper jaw	Lower jaw
Aplasia	52 (10.7 %)	77 (15.8 %)
Impacted		67 (13.8 %)
Erupted	228 (46.9 %)	215 (44.2 %)
Unerupted	201 (41.4 %)	115 (23.7 %)
Extracted	5 (1 %)	12 (2.5 %)
Total	486	486

A survey of the third molar development in the whole group is given in Tables I and II. In the upper jaw both wisdom teeth have been extracted in one case and one wisdom tooth in three cases. In the lower jaw both wisdom teeth have been extracted in one case and one wisdom tooth in ten cases. The x-ray control at the age of 12 makes it possible to determine that the absence

Table II

Development of lower third molars in the Swedish growth study group.
(Number of individuals.)

		Left M_3				
		A	I	E	U	Ex
Right M_3	A	28 (11.5 %)	3	2	9	
	I		25 (10.3 %)	7	1	
	E		4	81 (33.3 %)	16	4
	U	7	2	14	33 (13.6 %)	
	Ex			6		1 (0.4 %)

A = aplasia; I = impacted; E = erupted; U = unerupted; Ex = extracted.

of M_3 in these cases is not due to aplasia, and the incidence of aplasia of M_3 can therefore be computed for the total group.

In the upper jaw aplasia of the third molar occurs in 11 per cent, in the lower jaw in 16 per cent, calculated by numbers of teeth. Aplasia of one or two lower wisdom teeth occurs in 20 per cent of the cases. These frequencies are in rather good accordance with observations from a similar material recently published by *Grahnén* (1956), though this author recorded a somewhat lower incidence of aplasia of the mandibular M_3 (11 per cent). The estimation of third molar impaction should be made in relation to other developmental variations of the third molar as well as to the condition of the remaining dentition. At 20 years less than half of the wisdom teeth has erupted normally in each jaw, Table I. In this survey a tooth is recorded as erupted when in normal position and visible in the oral cavity. Information about the position of the extracted third molars is not available. Accordingly, they have not been recorded as impacted.

Unlike the frequency values concerning aplasia, frequency calculations of impaction depend on the definition, on the age

Table III

Impaction of lower third molars related to bite condition in the Swedish growth study group.

(Number of individuals.)

	Complete Dentition (133 cases)	Incomplete Dentition (110 cases)	Total (243 cases)
Impaction:			
Both sides	17 (12.8 %)	8 (7.3 %)	25 (10.3 %)
One side	8 (6 %)	9 (8.2 %)	17 (7 %)
Total	25 (18.8 %)	17 (15.5 %)	42 (17.3 %)

of the individuals, and on the condition of the bite. Impaction of the mandibular third molars according to the definition applied affects a total of 67 teeth (14 per cent), Table I, in 42 individuals (17 per cent). Table III gives the incidence of cases with impaction of the mandibular M_3 in regard to the condition of the dentition anteriorly of M_3. In 133 cases (55 per cent) the mandibular dentition is complete, apart from variations in development of the third molar. The number of impacted teeth is larger among complete (16 per cent) than among incomplete dentitions (11 per cent). Loss of teeth, apart from third molars, during development (aplasia or extraction) therefore reduces — as might be expected — the frequency of third molar impaction. In cases without loss of teeth anteriorly of M_3 there is bilateral impaction in 13 per cent and unilateral impaction in 6 per cent, i. e. a total of 19 per cent. These values should be considered minimum values with due regard to the applied definition and to the age of the group examined.

RESULTS

1. Impaction related to M_3-space.

The concept that insufficient space for the third molar in the lower jaw is an essential cause of its incomplete eruption has been corroborated in this investigation.

The M_3-space has been measured only in cases of complete dentition anteriorly of M_3. The registration has been made from the cephalometric x-ray films at the 20 years stage, as described

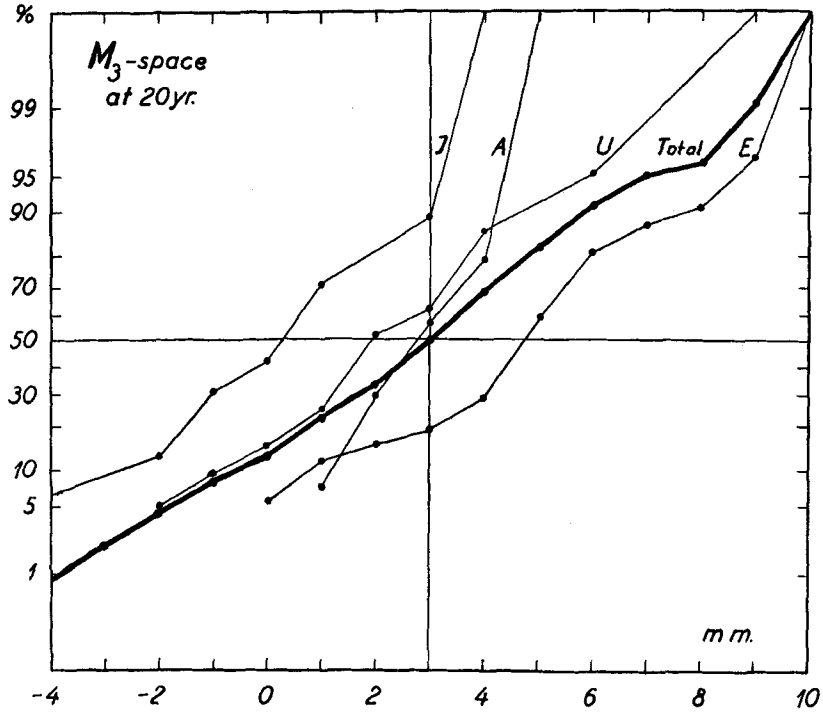


Fig. 6. Probit-diagram showing the distribution of third molar space at 20 years in 114 cases without loss of mandibular teeth anteriorly of M_3 (Total), and in subgroups: (I) impaction of both lower M_3 in 17 cases, (A) aplasia of both lower M_3 in 14 cases, (U) both lower M_3 unerupted and in normal position in 21 cases, and (E) both lower M_3 normally erupted in 32 cases.

above. In 114 of these cases in which the measurement was technically possible to obtain, the arithmetic mean was calculated to 3.3 mm with a standard deviation of 2.6 mm. The median value is 3 mm and the range — 4 to 10 mm. The distribution of the whole group (114 cases) is practically normal, as appears from the probit-diagram in Fig. 6.

In order to estimate the M_3-space in relation to the third molar development the group was divided into subgroups, (I) impaction of both M_3s, (A) aplasia of both M_3s, (U) both M_3s in normal position but unerupted, (E) normal eruption of both M_3s, and, besides, a heterogeneous rest group consisting of the remaining cases (unilateral aplasia, impaction or eruption). The distribution of the size of the M_3-space in the various subgroups, apart

from the rest group, appears from the probit-diagram in Fig. 6, together with the distribution for the total material.

The impaction group deviates, as shown in Fig. 6, from the other distributions, the M_3-space exhibiting a median value of 0 mm. The range is from — 4 to 4 mm. This distribution is significantly different from the remaining material, as estimated by the χ^2 test.[1]

It appears from Fig. 6 that the M_3-space in 90 per cent of the cases with bilateral impaction is smaller than the median for the total group, in 80 per cent smaller than the median for the group with unerupted third molars in normal position, and in no case reaches the level of the median value for the group of cases with fully erupted third molars.

From the above it is evident that the M_3-space in cases of impaction of the mandibular third molars is markedly diminished.

Furthermore, it is interesting to note that the M_3-space is larger in the group with fully erupted third molars than in the group with third molars unerupted but in normal position. The median values are 4.4 mm and 2 mm, respectively. The distributions are significantly different, as estimated by the χ^2 test.

In this connection a particular question may be asked. Should this difference in M_3-space at various stages of maturation of M_3 be related to the maturation of the mandible in general at 20 years, or is the dissimilarity localized to the third molar region? (cf. discussion of Table VII, pag. 254). Both factors may play a role, but the question can not be answered in this study. However, it should be noticed that the M_3-space is smaller in the aplasia group than in the one with fully erupted third molars. These distributions are significantly different, as estimated by the χ^2 test. Besides, not a single case with extremely large M_3-space can be found in the aplasia group. This is in favour of the conception that the normal eruption of the third molar per se is important for the size of the M_3-space. It is possible that the eruption of M_3 may influence the resorptive rebuilding of the retromolar area. It is also possible that the eruption of M_3 may influence the direction of the eruption of the anterior teeth and thereby increase the size of the M_3-space. For the analysis

[1] A difference is considered significant (**) if the probability of the difference being due to chance is less than one per cent ($P < 0{,}01$).

of these questions growth studies with metallic implants may be valuable.

Conclusions: In cases of impaction of the mandibular third molar the space in the alveolar arch, behind the second molar, is considerably reduced. Therefore, lack of space for the third molar must be regarded as an essential cause of its impaction.

2. The M_3-space related to size and shape of the mandible.

The development of the third molar space may be related to three essential factors in mandibular growth, as stated in the introductory discussion. To elucidate this the relation between the size of M_3-space and each of these three factors has been analysed at the 20 years stage of development in 114 cases with complete dentitions anteriorly of M_3, Table IV.

Table IV

Correlations between M_3-space and three factors in mandibular development. (Swedish growth study group.)

	r
1. Mandibular base length (cd-pgn) ...	0.28**
2. Mandibular base angle (β_2).....	— 0.29**
3. Alveolar prognathy (CL/ML_2).....	0.06

Calculated from 114 cases with complete lower dentitions anteriorly of M_3. r = coefficient of correlation.

It appears from this calculation[1] that the M_3-space is diminished when the mandible is short and when the bend of the mandibular base is pronounced, that its variation, however, is independent of the degree of alveolar prognathy as evaluated by direct measurement. On the other hand, it is known that these three factors in mandibular development are mutually correlated (*Lindegård* 1953). These correlations are given in Table V for the present 114 cases.

The interrelation indicates that in case of large jaw length the alveolar prognathy is often diminished and, consequently, the eruption of the teeth has been compensatorily backward directed. Also in case of a slightly bent mandibular base (sagit-

[1] When the probability of a coefficient of correlation differing from zero is more than 99 per cent the correlation is considered significant (**).

Table V

Interrelations of mandibular developmental factors. (Swedish growth study group.)

	r
1. (cd-pgn) and 2. (β_2)	— 0.21*
1. (cd-pgn) and 3. (CL/ML$_2$)	— 0.34**
2. (β_2) and 3. (CL/ML$_2$)	0.33**

Calculated from 114 cases with complete lower dentitions anteriorly of M_3. r = coefficient of correlation.

tal direction of condylar growth) the alveolar prognathy is frequently diminished. This compensatory development of alveolar and dental arches eliminates the direct correlation between M_3-space and alveolar prognathy. The relation between M_3-space and alveolar prognathy, therefore, should be demonstrable by means of computation of partial correlation in such a way that the variation in size of M_3-space is related to that variation in alveolar prognathy which is independent of length and shape of the mandible. These correlations are shown in Table VI, from which it appears that the M_3-space is significantly dependent on all three factors in mandibular development.

Table VI

Partial correlations between M_3-space and three factors in mandibular development. (Swedish growth study group.)

	r_p
1. Mandibular base length (cd-pgn)	0.31**
2. Mandibular base angle (β_2)	— 0.31**
3. Alveolar prognathy (CL/ML$_2$)	0.27**

Calculated from 114 cases with complete lower dentitions anteriorly of M_3. r_p = partial coefficient of correlation.

Conclusions: The space for the mandibular third molar, the M_3-space, is diminished (1) by low growth rate in length of the mandible, (2) by vertical direction of condylar growth or (3) by backward directed eruption of the dentition.

In the clinical evaluation of the importance of the backward directed eruption for third molar impaction the correlative interdependence between these factors must be considered.

The three factors are separately influencing the development of the M_3-space. In individual cases they may either amplify or neutralize each other.

3. Impaction related to mandibular growth.

In the preceding section it was shown that the third molar space in the lower jaw may be related to three factors in mandibular development. The M_3-space registered, however, only provides an indirect measure of the space available for M_3. Furthermore, it is possible that the normal eruption per se may influence the size of the M_3-space, as discussed previously. It is therefore of importance to relate the frequency of M_3-impaction directly to the developmental factors of the lower jaw, namely its size and shape as well as the directional trend of eruption of the teeth. From a prognostic point of view the question also arises whether the risk of impaction may be estimated at an early developmental stage, i.e. at an age in which any reduction in the number of teeth is of current interest to the orthodontist. These questions will be evaluated from the regression diagrams of the adolescent growth of the mandible, Figs. 7, 8 and 10.

The growth analysis is represented by two cross-sections on the distance curve, showing the developmental changes of the group during adolescence. In the diagrams the mean (M_{12}) on the x-axis represents the level at 12 years and the standard deviation (σ_{12}) the individual variation. The mean on the y-axis (M_{20}) represents the level at 20 years and the corresponding standard deviation (σ_{20}) the individual variation. The area of distribution for the individual variation is illustrated by the contour ellipsis, inside which 95 per cent of the cases are found, corresponding to two standard deviations. The slope of the contour ellipsis is characterized by the orthogonal regression coefficient b^1 (cf. *Björk & Palling* 1954). The contour ellipses in Figs. 7 and 8 are based on the whole group (243 cases). As mutilations of the dental arch through loss of teeth will affect the distribution in degree of alveolar prognathy, the contour ellipsis in

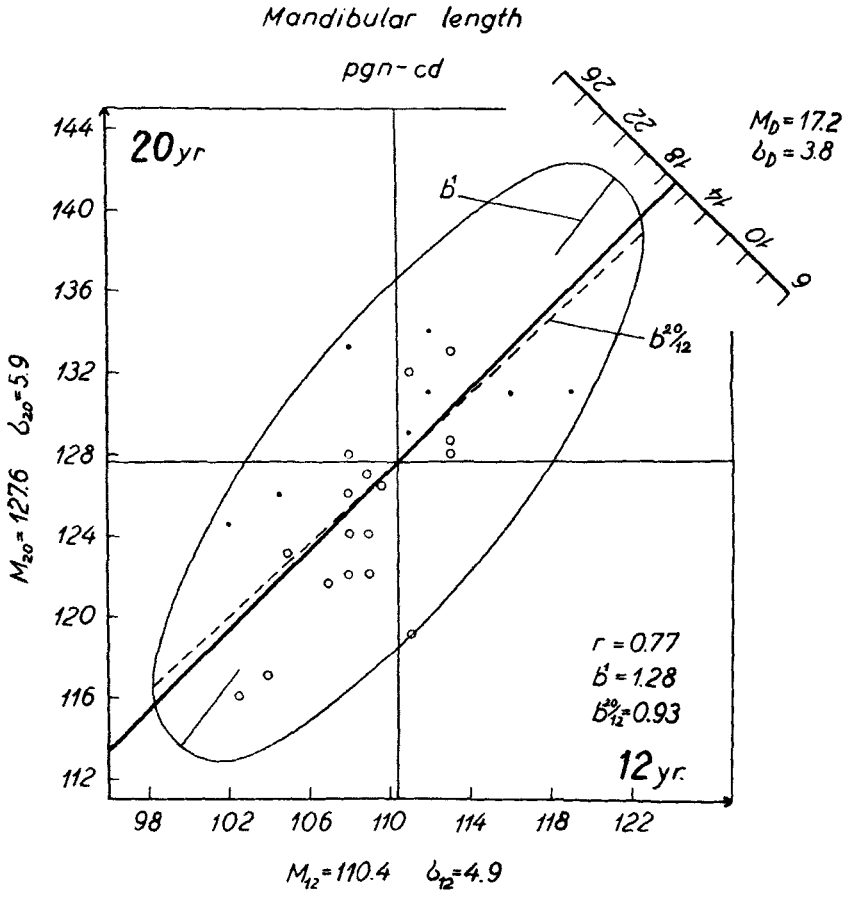


Fig. 7. Lower third molar impaction (bilateral = o, unilateral = •) related to growth rate in mandibular length. Above the diagonal line (heavy line) the growth rate is higher and below this line lower than average.

Fig. 10 only includes cases with complete dentition anteriorly of M_3 (133 cases).

The diagonal line of difference (heavy line) represents the average growth change (M_D), and the individual variation in growth change is expressed by the standard deviation (σ_D). The part of the series which shows a change larger than average is situated above the line of difference, whereas the cases characterized by a smaller change are below this line. The inclination of the line of difference is 45 degrees as the scale is

the same for both axes. The standard deviation (σ_D) of the distribution of growth change may be computed from the formula: $\sigma_D = \sqrt{\sigma^2_{12} + \sigma^2_{20} - 2r\sigma_{12}\sigma_{20}}$. *Cf. Moorrees & Reed* (1954).

The regression line (stippled line) which represents the average level at 20 years for a given level at 12 is coinciding with the difference line provided the regression coefficient $b_{20/12} = 1.0$ (cf. *Björk* 1953). On these assumptions the dispersion around the regression line is equal to the dispersion of the growth change ($\sigma_{20}\sqrt{1 - r^2} = \sigma_D$).

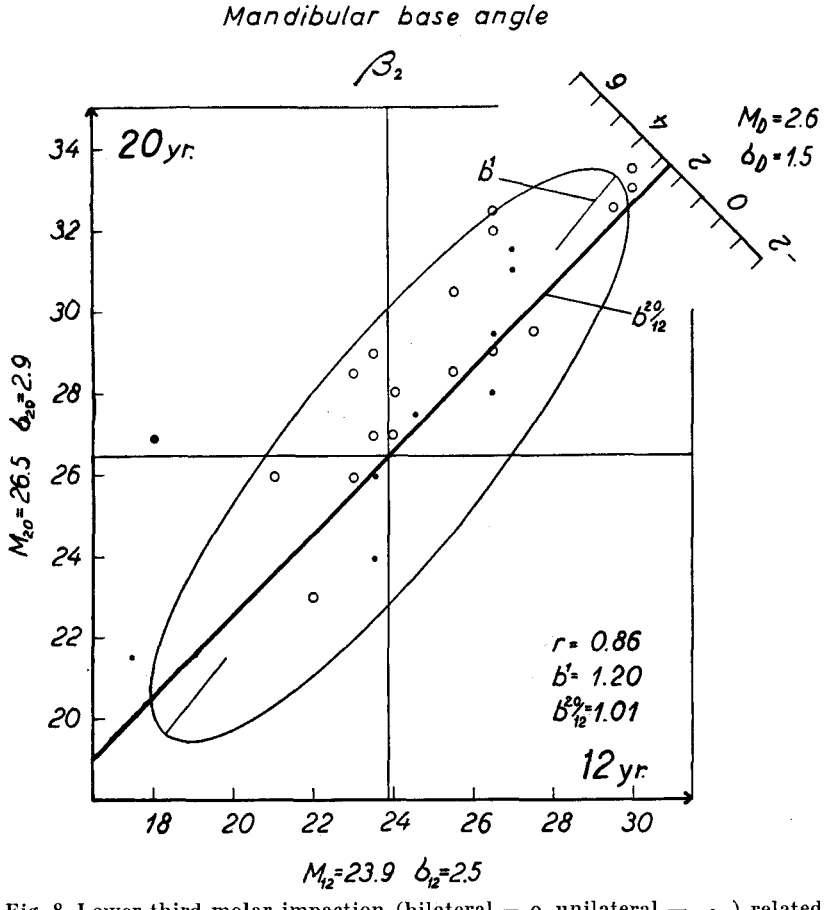


Fig. 8. Lower third molar impaction (bilateral = o, unilateral = •) related to developmental change in mandibular shape. Above the diagonal line (heavy line) the direction of condylar growth is evaluated to be more vertical and below this line less vertical than average.

Further, the average growth change (growth rate) towards 20 years is the same regardless of the individual level at 12 years. The correlation between growth change (rate) and level value at 12 years ($r_{D,12}$) is for this reason not significantly different from 0. It applies to all three diagrams that the inclinations of regression line and difference line are not significantly different. As regards the mandibular base angle, Fig. 8, the lines are completely coinciding. As to jaw length, Fig. 7, and alveolar prognathy, Fig. 10, a minor divergence is present, within limits of the error of measurement. In other words, the level at 12 years supplies no hint regarding the estimation of size and direction of the adolescent growth (cf. *Björk* 1953).

We will now pass on to the immediate relations of third molar impaction to mandibular growth. In the growth diagrams, Figs. 7, 8 and 10, the position of cases with impaction of both M_3s is indicated by circles, with impaction of one M_3 by dots. Only such cases of impaction are denoted in which the dentition anteriorly of M_3 is complete.

As regards the mandibular growth in length, Fig. 7, we find an appreciable association with third molar impaction. Out of 17 cases with bilateral impaction we find the jaw shorter than the average at the age of 12 in 12 cases, and at the age of 20 the jaw shorter than the average in 12 cases as well. The growth rate of the mandibular length is lower than average in 11 out of 17 bilateral cases. Even clearer is this association when two sectors of the ellipsoid distribution are compared. In individuals with a jaw shorter than average at the age of 12 and 20, with a growth rate lower than average as well, we find eight cases of bilateral impaction. In individuals with a jaw larger than average at the age of 12 and 20 and a growth rate higher than average we find only two cases of impaction. This distribution of cases with impaction shows that the development in jaw length is a factor of importance but that other factors too must play a role.

When proceeding to the direction of condylar growth, registered as the mandibular base angle, Fig. 8, we find a marked association with impaction even here. Out of 17 cases with bilateral impaction 11 display a β_2 angle larger than average at 12 years, and 14 at 20 years. In 14 cases the increase with age of the β_2 angle is larger than average. In regarding sectors of the

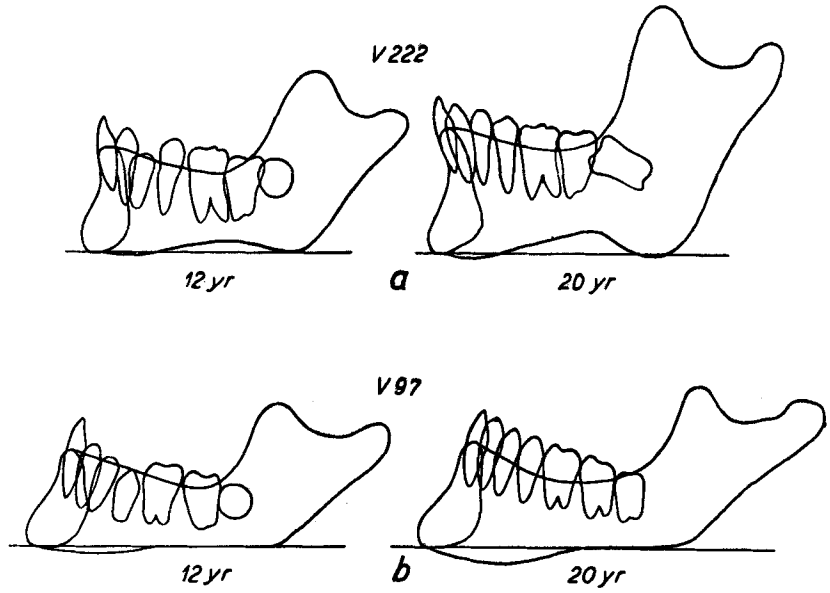


Fig. 9. Effect of developmental changes in mandibular shape on third molar eruption illustrated by two individual cases: (a) vertical direction of condylar growth assosiated with impaction of both M_3, (b) sagittal direction of condylar growth associated with ample space for the erupting third molars.

ellipsoid distribution we find one case only of third molar impaction in which the β_2 angle is smaller than average at the age of 12 and 20, and in which the growth change as well is less than average. Bilateral impaction occurs in no less than 9 cases with a β_2 angle larger than average at both age stages and a larger increase than average. It should also be observed that in a few cases of impaction the deviation in β_2 angle is extreme and exceeds the limit of the 95 per cent ellipsis. The association between impaction and direction of condylar growth is thus considerable. This is the more remarkable as the evaluation of this factor by means of the β_2 angle must be considered fairly rough, and the actual association may be expected to be even closer.

The importance of the direction of condylar growth to the formation of the M_3-space and to the prospect of third molar eruption during adolescent growth is illustrated by two individual cases, Fig. 9. The upper case shows the development

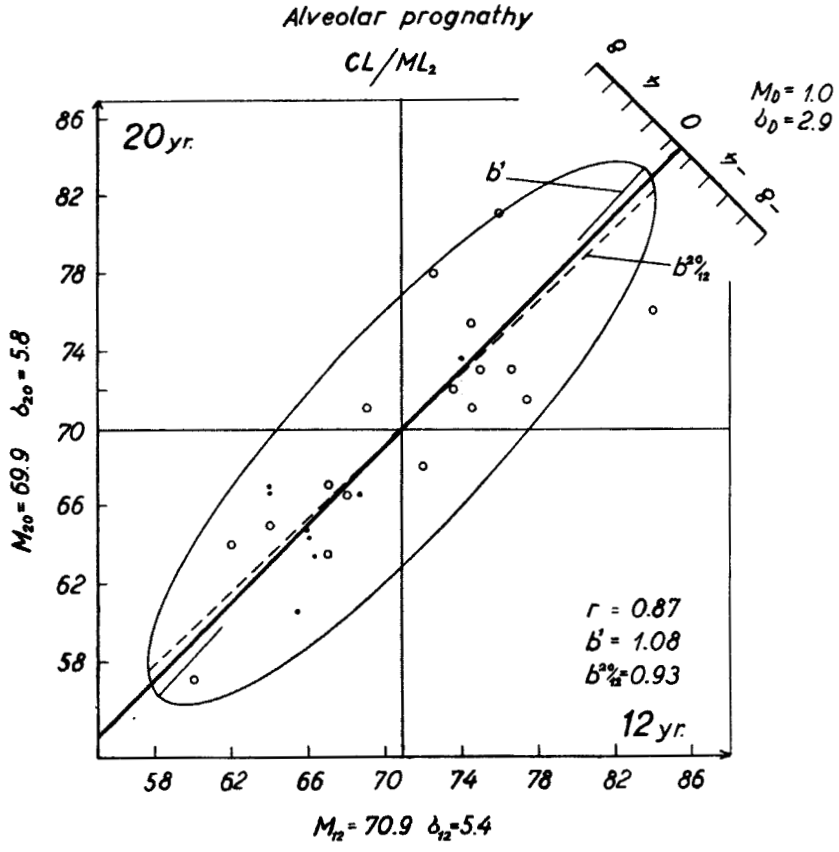
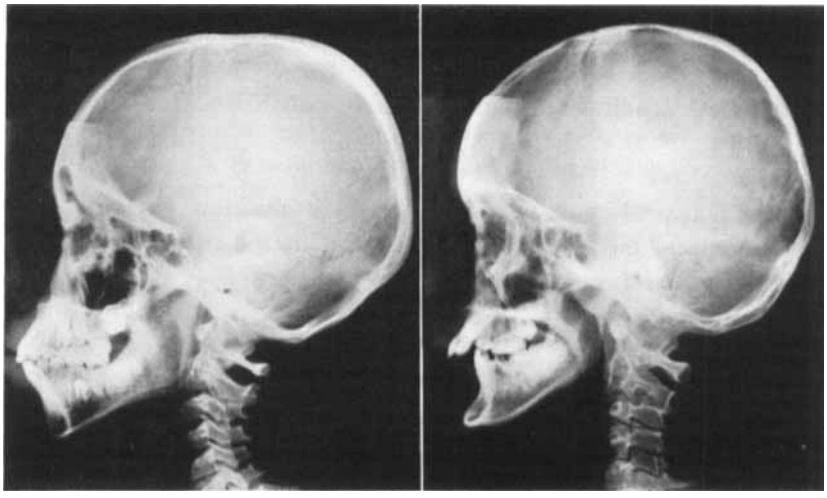


Fig. 10. Lower third molar impaction (bilateral = o, unilateral = •) related to developmental change in alveolar prognathy. Above the diagonal line (heavy line) the alveolar prognathy is increasing more and below this line less than average.

of the mandible by extreme vertical direction of condylar growth, the lower case the development by sagittal direction of growth. At 12 years the third molar germs are situated almost alike in relation to the anterior border of the ramus. In the case of vertical growth of the condyle the M_3-space is greatly reduced at adult age, and both M_3s are impacted. In the case of sagittal growth the M_3-space is markedly increased at adult age and ample space for M_3 is found. The compensatory development of the alveolar prognathy should also be noticed, in the first case in a prognathous, in the second case in a retrognathous direction.



a b

Fig. 11. Two clinical cases (of Danish descent) illustrating various degrees of mandibular alveolar prognathy: (a) alveolar prognathy associated with protruded position of the dentition, and (b) alveolar retrognathy associated with retruded position of the lower dental arch in relation to the basal structure.

The evaluation of the directional trend of eruption of the dentition as a factor concerning third molar impaction should be made with special reference to its correlation with the mandibular growth as a whole, as discussed previously. Any direct association between the degree of alveolar prognathy and the occurrence of third molar impaction therefore cannot be expected, nor does it appear from the regression diagram, Fig. 10.

The variation in development of alveolar prognathy is illustrated by two clinical cases, Fig. 11.

Conclusions: As far as prognosis is concerned, the risk of third molar impaction may be foreseen even at a pre-adolescent stage of development in case of an extremely short jaw length or an extremely large mandibular base angle. An extreme alveolar retrognathy at the same developmental stage would probably involve the risk of third molar impaction if the effect is not neutralized by a development in length and shape of the mandible, favourable of the M_3-space. As the pre-adolescent shape and size of the mandible provide no help when estimating the rate and direction in adolescent growth, the correct interpretation

of the individual pattern of growth greatly facilitates the prognostication. The three factors in mandibular development should be regarded in orthodontic treatment planning, and prophylactic extraction of teeth should be considered.

4. Impaction related to maturation of M_3.

The maturation of the third molar is another particular developmental factor which has been considered in this study and which bears some relation to incomplete eruption of the mandibular third molars.

The maturation of M_3 at the pre-adolescent stage of development has been evaluated from its stage of mineralization. The mineralization of M_3 at the age of 12 has been determined according to the below classification, which is a simplification of the one presented by *Gleiser & Hunt* (1955) concerning the mineralization of the mandibular first molar.

I. No mineralization.
II. Mineralization of cusps only.
III. Mineralization of half of tooth crown.
IV. Mineralization of crown completed.
V. Root formation started.

The distribution, computed from the total group, apart from 28 cases of bilateral aplasia of M_3 and one case of extraction of both M_3s, (214 cases) has its median value between stage II and III of M_3-mineralization at 12 years, according to the probit-diagram, Fig. 12. The distribution is markedly skew, having 20 per cent of the cases at the first stage of mineralization, and for this reason does not permit computations of correlation, such as the use of the coefficient of correlation, or application of arithmetic mean.

The material has been divided into subgroups according to the third molar development at adult age, Fig. 12. The median value of M_3-mineralization at 12 years in the group with bilateral impaction of M_3 is found between stages I and II. In 32 per cent the maturation of M_3 corresponds with stage I. In no case, in this group, the maturation exceeds stage IV. The impaction group thus shows a retarded maturation of M_3 at 12 years. The difference in distribution between this subgroup and the remaining

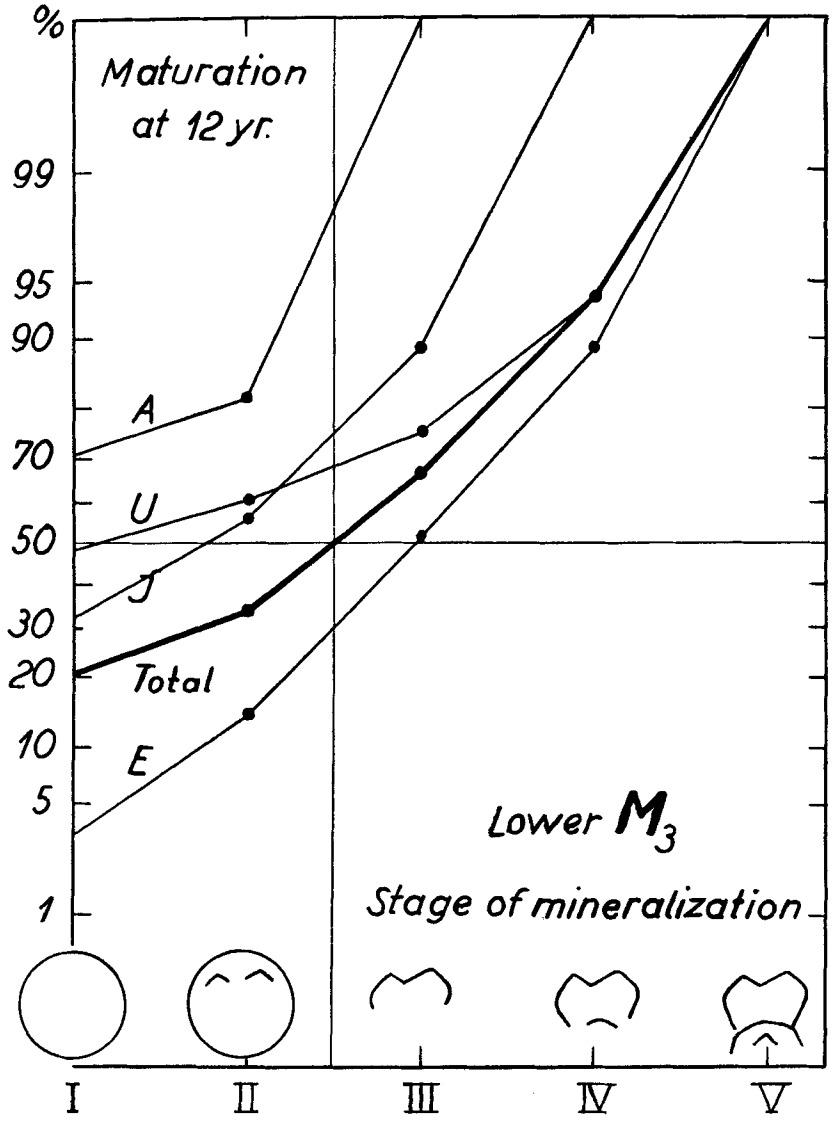


Fig. 12. Probit-diagram showing the distribution of third molar stage of mineralization at 12 years in 214 cases (Total), and in subgroups, classified according to lower third molar development at 20 years: (A) aplasia of one M_3 in 18 cases, (U) both M_3 unerupted and in normal position in 33 cases, (I) impaction of both M_3 in 25 cases, and (E) both M_3 normally erupted in 81 cases.

material — cases of unilateral aplasia and impaction excluded — is significant, as judged by the χ^2 test.

An association was found, as was to be expected, between maturation and eruption of M_3. In the subgroup with fully erupted M_3s, Fig. 12, extremely retarded maturation, corresponding to stage I, only occurs in 3.5 per cent of the cases compared to 50 per cent in the subgroup with unerupted M_3s at 20 years.

An association is also found between M_3-maturation and eruption of the other teeth, appearing from the fact that the number of unerupted permanent teeth is larger in 12 year old boys with retarded mineralization of M_3 than in those having a more advanced stage of M_3-mineralization at the same age. A reliable measurement of the strength of this association cannot be obtained as all permanent teeth, apart from M_3, have erupted in about half of the group at the 12 years stage.

On account of this association, retarded maturation of M_3 as well as retarded dental maturation in general must be considered of prognostic importance when the risk of third molar impaction is estimated. It has not been possible here to ascertain whether the cause of third molar impaction has to be referred to a retarded maturation of M_3 per se or to a general retardation in dental development.

Before accepting retarded maturation of M_3 as a fourth factor of importance to third molar impaction we should like to show that we are not dealing with just another means of estimating retarded jaw growth. Othervise, it might be possible that factor I as well as IV in reality are nothing but different expressions of the same developmental factor. In Table VII, the development in mandibular length has therefore been related to the stage of M_3-mineralization at 12 years. The average length of the lower jaw is not significantly different, neither at 12 nor at 20 years, in cases of early and late maturation of M_3. The adolescent growth rate in length of the mandible is identical regardless of the degree of M_3-mineralization at 12 years.

An association between maturation of M_3 and development in length of the jaw may, however, be assumed to exist although no significant one appears in Table VII. Since any such possible interrelation is very likely to be weak it seems to be justified

Table VII

Mandibular base length related to lower third molar development. (Swedish growth study group.)

Development of M_3	Number	Mandibular length (cd-pgn) in mm.		
		12 yrs.	20 yrs.	Growth rate from 12 to 20 yrs.
		M ± S. E.	M ± S. E.	M ± S. E.
Mineralization stages at 12 yrs.				
I + II	74	109.3 ± 0.68	126.8 ± 0.71	17.5 ± 0.40
III	70	110.6 ± 0.65	127.7 ± 0.69	17.1 ± 0.50
IV + V	71	111.5 ± 0.61	128.6 ± 0.76	17.1 ± 0.48
Bilateral aplasia of M_3	28	110.0 ± 0.81	127.0 ± 0.75	17.0 ± 0.60
Total	243	110.4 ± 0.31	127.6 ± 0.38	17.2 ± 0.24

M = arithmetic mean.
S. E. = standard error of the mean.

to consider retarded maturation of M_3 as a particular fourth factor in third molar impaction.

Attention should also be directed towards the cases showing aplasia of one of the mandibular third molars. In cases of unilateral aplasia of M_3 the mineralization stage of M_3 on the opposite side of the jaw was registered. The distribution is shown in Fig. 12, from which it appears that 70 per cent of the cases are found at maturation stage I. The distribution is significantly different from the remaining material, cases of uni- and bilateral impaction being excluded. On the other hand, the growth in length of the jaw shows no association with aplasia of M_3, Table VII.

Conclusions: An association has been demonstrated between impaction and retarded maturation of the third molar. Retarded maturation of M_3, and possibly general retarded development of the dentition, is found to be a fourth factor of significance in the prognostication of third molar impaction.

5. Combination of factors.

In the preceding sections four factors have been isolated each of which was proved associated with third molar impaction.

In this section an attempt will be made to answer two questions of clinical and prognostic importance. It is desirable to know if any of the factors are more essential to third molar impaction than others and, if so, to determine their ranking order. Besides, we are interested to know how great is the part of the total frequency of impaction which can be accounted for by a combination of the four factors, with due regard to the limitations set by the errors of measurement. In this section an analysis will be made of the group with bilateral impaction in an otherwise complete dentition of the mandible at the adult stage of development with the view of answering these questions.

First the mutual ranking order of the three skeletal factors will be evaluated, regardless of these factors being interrelated. The individual deviations from their respective means at the 20 years stage have been computed for each of the factors. These deviations are expressed by the standard deviation as a unit. The calculations show that the impaction group, on an average, is characterized by a short jaw (mean deviation = —0.54 standard units), a very large β_2 angle (mean deviation = 0.95 standard units), and a compensatory slight increase in alveolar prognathy (mean deviation = 0.27 standard units). Confer the distributions of impaction cases in Figs. 7, 8 and 10. Therefore, if the interrelation is ignored, factor II, i.e. the vertical direction of condylar growth, is of greatest importance to impaction, followed by jaw length which in turn is followed by directional trend of eruption of the dentition.

From a developmental viewpoint the growth in length and the change in shape of the mandible are associated. Likewise, the degree of alveolar prognathy is associated with the development in length as well as in shape of the mandible. For the evaluation of our present problem it is therefore justified to make a correction concerning these associations. The correction has been made by the method of forming residual functions, as described by *Lindegård* (1953), and the results are presented in Table VIII. Before accounting for these results we will describe the manner by which the evaluation has been accomplished.

In column 1, Table VIII, the individual deviations in length of the mandible are specified, as calculated from the function F cd-pgn (β_2). This function gives the length of the mandible

Table VIII

Individual combination of four developmental factors in cases with bilateral impaction of lower third molars at 20 years. (Swedish growth study group.)

Case no.	1 Factor I F cd-pgn (β_2)	2 Factor II F β_2 (cd-pgn)	3 Factor III F CL/ML$_2$ (cd-pgn, β_2)	4 Factor I + II + III Standard score	5 Factor IV Maturation stage of M_3 at 12 yrs.	6 M_3-space mm
1	— 0.38	1.74	0.19	1.93	I	1
2	0.02	2.03	0.56	1.45	III	3
3	0.13	1.71	0	1.58	II	3
4	— 0.83	0.28	0.75	— 0.36	I	0
5	0.04	0.32	0.19	0.09	II	4
6	0.97	0.71	— 0.94	0.68	III	— 1
7	— 1.77	— 1.78	— 1.50	1.49	III	0
8	0.07	— 0.36	— 0.38	— 0.06	I	1
9	0.97	— 0.14	— 1.31	0.20	I	— 1
10	— 0.43	0.53	— 0.75	1.71	II	— 4
11	0.56	2.14	— 0.19	1.77	III	3
12	— 0.88	0.43	2.06	— 0.76	III	1
13	— 0.76	0.64	— 0.56	1.96	I	4
14	— 1.84	— 0.43	0.56	0.85	II	1
15	— 0.58	— 0.18	— 0.38	0.76	II	— 2
16	— 1.64	1.49	— 0.19	3.32	I	1
17	0.47	1.25	0.56	0.22	III	— 1
Mean	— 0.35	0.61	— 0.08	1.03	II	0.8

in relation to the individual shape (β_2). The standard deviation of the residual distribution is 5.6 mm.

In column 2 of the same table the individual deviation in shape of the mandible is shown in relation to the length, as calculated from the function F β_2 (cd-pgn). The standard deviation of the residual distribution is 2.8°. This correction is justified in order to show that the impaction is connected with the vertical direction of condylar growth, independent of the fact that usually the jaw is shorter at the same time.

The individual deviation in alveolar prognathy, column 3, was calculated from the function F CL/ML$_2$ (cd-pgn, β_2). The de-

viation in alveolar prognathy was thereby expressed in relation to the individual length as well as to the shape of the lower jaw. The standard deviation of the residual distribution is 5.3°.

We will now study Table VIII in the vertical direction and look at the mean values of the individual deviations appertaining to the three skeletal factors. Column 1 shows that on the average the mandible in these cases of impaction is short (mean deviation = —0.35 standard units). The β_2 angle, column 2, is large (mean deviation = 0.61 standard units), while the alveolar prognathy, column 3, is average (mean deviation = —0.08 standard units). Even when correction is made for interrelation, the development in shape of the mandible remains the skeletal factor of greatest importance to impaction, followed by jaw length and then by alveolar prognathy.

In order to evaluate the effect of the combinations of the three factors we will then study Table VIII in the horizontal direction. In the individual cases of impaction we add the deviations of all three skeletal factors, as expressed by the respective standard units (= sigma units). As a matter of consistency, we reckon the deviations with a contributory effect to impaction as positive numbers, deviations with a counteracting effect as negative numbers, irrespective of sign. In this way we will obtain a standard score which is an expression of the combined effect of the three factors, column 4. In the majority of cases this value is positive (15 cases out of 17). The mean value of these 17 cases is 1 standard score. If we establish a standard score of 1 as the lower limit we find that a combination of the skeletal factors of development will account for the impaction of M_3 in 8 cases, i.e. 47 per cent.

In column 5 the degree of M_3-mineralization at 12 years, previously proved to be associated with third molar impaction, is presented. If we accept the mineralization stages I and II as an indication of retarded maturation of M_3 we find that this fourth factor is of importance in two thirds of the cases. Therefore, the four factors in combination account for M_3-impaction in 14 cases (82 per cent).

Conclusions: An evaluation of the reciprocal influence of the three skeletal factors on third molar impaction demonstrates that vertical direction of condylar growth has the greatest effect,

followed by short jaw length and then by reduced alveolar prognathy. This ranking order is maintained even after correction has been made for the interrelation of the three factors.

Apparently, combinations of the three skeletal factors together with the fourth factor, retarded maturation of M_3, account for the impaction in four fifths of the cases of bilateral M_3-impaction.

6. Other factors.

Naturally, the developmental factors described above are not the only ones which may have a relation to third molar impaction. For instance, we have not discussed the importance of the tooth size or the shape of the dental arch. One particular factor, however, has been considered, namely the angular position of the third molar at the time of its mineralization. At this time the tooth germ is tilted anteriorly. This has been described by *Hellman* (1936) as a physiological characteristic. The degree of this tilt has been studied at the 12 years stage in our material. No difference in inclination has been demonstrable between cases which show M_3-impaction at adult age and the remaining material.

Conclusions: The prospects of estimating the risk of impaction from the degree of inclination of M_3 at a pre-adolescent stage do not appear to be promising.

Part III

DENTAL STUDENT GROUP

MATERIAL

It has been deemed desirable to test the previously described principles of the etiology of third molar impaction on more than one group of individuals. For this purpose the development of the mandibular third molar has been examined in 338 male students at the Royal Dental College, Copenhagen. The following report is confined to cases exhibiting a complete mandibular dentition anteriorly of M_3. This group comprises 237 cases or 67 per cent of all individuals examined. The age varies from 19 to 30 years. The development of the mandibular third molar in this group, as checked by means of intraoral x-ray films, appears from Tables IX and X.

Table IX

Development of lower third molars in the Danish dental student group.
(Number of M_3s.)

	Lower jaw
Aplasia	72 (15.2 %)
Impacted	106 (22.3 %)
Erupted	180 (38.0 %)
Unerupted	83 (17.5 %)
Extracted	33 (7.0 %)
Total	474

72 mandibular third molars were missing due to aplasia, i.e. 15 per cent, as calculated by numbers of teeth, in 48 individuals (20 per cent). These values are in complete accordance with the corresponding data computed from the adolescent growth study group, Part II.

A greater number of mandibular third molars has been extracted in this group, as compared to the adolescent growth study group (7 per cent to 2.5 per cent). The number of unerupted M_3s is smaller (17.5 per cent to 24 per cent).

Table X

Development of lower third molars in the Danish dental student group.
(Number of individuals.)

		Left M_3				
		A	I	E	U	Ex
Right M_3	A	24 (10.1 %)	5	5	4	
	I	4	38 (16.0 %)	6	4	1
	E	4	4	73 (30.8 %)	1	5
	U	2	3	7	31 (13.1 %)	
	Ex		3	2		11 (4.6 %)

A = aplasia; I = impacted; E = erupted; U = unerupted; Ex = extracted.

The number of impacted third molars is large (22 per cent) compared to the number among the complete dentition cases in the adolescent growth study group (16 per cent). Bilateral impaction occurs in 16 per cent of the cases, unilateral impaction in 13 per cent, i.e. a total of 29 per cent. In the adolescent growth study group the frequency of uni- or bilateral impaction was calculated at 19 per cent, in cases of complete dentition anteriorly of M_3. This dissimilarity in occurrence of impacted third molars might be attributed partly to the difference in age distribution, partly to the difficulty in defining the concept of impaction.

No significant difference in occurrence between right and left third molar development was observed in this material (Table X) or in the material described in Part II (Table II).

RESULTS

1. Impaction related to M_3-space.

Bilateral impaction of the mandibular third molar occurs in 38 cases (16 per cent) of this series. These cases form an impaction group which was submitted to cephalometric x-ray examination. The M_3-space was determined from the films in a similar manner as described previously. The individual values are presented in Table XI, column 5. They vary from — 3 to 4 mm, with an arithmetic mean of 1 mm. The median value is 1.2 mm. The majority of these cases of impaction has an extremely small M_3-space. In 90 per cent of the cases the M_3-space is smaller than the median value for the total 20 years group. For all practical purposes, the distributions of the M_3-space in the impaction groups of both series are therefore identical, cf. Fig. 6.

Conclusions: A strong association between mandibular third molar impaction and small M_3-space is explicit also in this group.

2. Impaction related to a combination of factors in mandibular development.

The main purpose of this study is to determine the essential factors in development which concern the space for the lower wisdom tooth. In the preceding sections three skeletal factors have been demonstrated which have been ranked according to their importance to impaction. In addition, the maturation of

M_3 has been demonstrated to be a fourth factor. As the error of measurement concerning the pattern of skeletal growth must be considered fairly large in the routine method of x-ray cephalometrics the question is pertinent whether this ranking order will remain the same when applied to another material. Furthermore, we have demonstrated that the different factors in combination will account for the impaction in the majority of cases. It seems to be important to elucidate this question, too, from more than one sample.

For this purpose the length and shape of the mandible as well as the alveolar prognathy have been measured from profile x-ray films of the impaction cases within the student material. A comparison has then been made with the mean values of the adolescent growth study group at the 20 years stage of development. The individual deviations are expressed by fractions of standard deviations. The impaction group within the student material is, on an average, characterized by a short mandible (mean deviation = —0.62 standard units), by a large β_2 angle (mean deviation = 0.95 standard units), and by a fairly average alveolar prognathy (mean deviation = —0.11 standard units). This is in concordance with the characteristics of the impaction group dealt with in Part II.

An analysis like this, however, should be made with a correction for the interrelation of the factors, as discussed previously. The correction has been performed in the same way as in Table VIII. The results are summarized in Table XI.

When examining Table XI in the vertical direction we find that the lower jaw on an average is short in the impaction group, even in relation to its shape, as evaluated from the function F cd-pgn (β_2), column 1 (mean deviation = —0.43 standard units). The shape of the mandible is characterized by a large β_2 angle (mean deviation = 0.61 standard units), as evaluated in regard to the length from the function F β_2 (cd-pgn), column 2. The alveolar prognathy is reduced (mean deviation = —0.36 standard units), as evaluated regarding the mandibular development in length as well as in shape. This calculation has been made from the function F CL/ML_2 (cd-pgn, β_2), column 3.

The ranking order of the three factors, with as well as without correction, is therefore identical with the one found in the pre-

Table XI

Individual combination of three developmental factors in cases with bilateral impaction of lower third molars.

(Danish dental student group.)

Case no.	1 Factor I F cd-pgn (β_2)	2 Factor II F β_2 (cd-pgn)	3 Factor III F CL/ML$_2$ (cd-pgn, β_2)	4 Factor I + II + III Standard score	5 M_3-space mm	6 Age
1	— 0.31	1.25	— 1.03	2.59	— 3.0	19
2	0.9	0.36	— 1.11	0.57	1.5	19
3	— 1.77	— 0.07	0.49	1.2	2.0	19
4	— 1.6	— 0.57	0.54	0.5	— 2.0	21
5	— 0.02	— 0.39	— 1.74	1.37	0	21
6	1.23	3.81	— 1.71	4.29	— 3.0	21
7	0.88	0.64	— 1.14	0.9	1.0	20
8	0.61	0.61	0.3	— 0.3	3.5	27
9	0.36	0.21	1.28	— 1.43	0	22
10	— 1.77	— 0.07	— 0.11	1.81	1.5	24
11	— 1.19	1.57	— 1.16	3.92	1.5	23
12	0.56	0.75	— 1.01	1.2	— 1.5	26
13	— 1.62	0.64	— 1.82	4.08	— 0.5	22
14	— 0.14	1.14	— 1.29	2.57	— 2.0	22
15	0.05	0.82	— 0.84	1.6	3.0	24
16	— 0.34	— 0.28	1.39	— 1.33	0	23
17	— 2.07	— 1.17	— 0.15	1.05	3.0	25
18	— 0.74	1.67	0.83	1.58	4.0	23
19	— 0.05	1.14	— 0.23	1.42	3.5	22
20	— 1.77	1.28	0.62	2.43	0	25
21	— 0.7	0.46	— 1.74	2.9	1.5	22
22	0.14	1.35	— 0.83	2.03	2.5	23
23	0.25	0.53	— 1.22	1.5	1.5	21
24	— 0.31	0.71	— 0.38	1.4	3.0	23
25	— 1.48	— 1.21	0.38	— 0.11	2.0	22
26	— 1.42	1.71	— 0.04	3.17	2.5	23
27	— 1.15	1.74	1.76	1.14	1.0	22
28	0.9	0.36	— 1.29	0.75	— 1.0	21
29	— 1.01	— 0.61	0.88	— 0.48	0.5	22
30	1.44	— 1.25	— 1.59	— 1.1	2.0	28
31	— 0.36	0.89	0.49	0.76	— 1.0	19
32	— 0.9	0.78	1.93	— 0.25	2.0	27
33	1.05	0.21	— 0.39	— 0.45	2.0	21
34	— 1.14	0.04	0.6	0.58	0	20
35	0.09	1.0	— 0.32	1.23	3.5	22
36	— 1.1	1.6	— 2.44	5.14	— 2.5	20
37	— 0.56	0.32	— 0.49	1.37	2.0	22
38	— 1.21	1.07	— 1.18	3.45	2.5	29
Mean	— 0.43	0.63	— 0.36	1.40	1.0	22.5

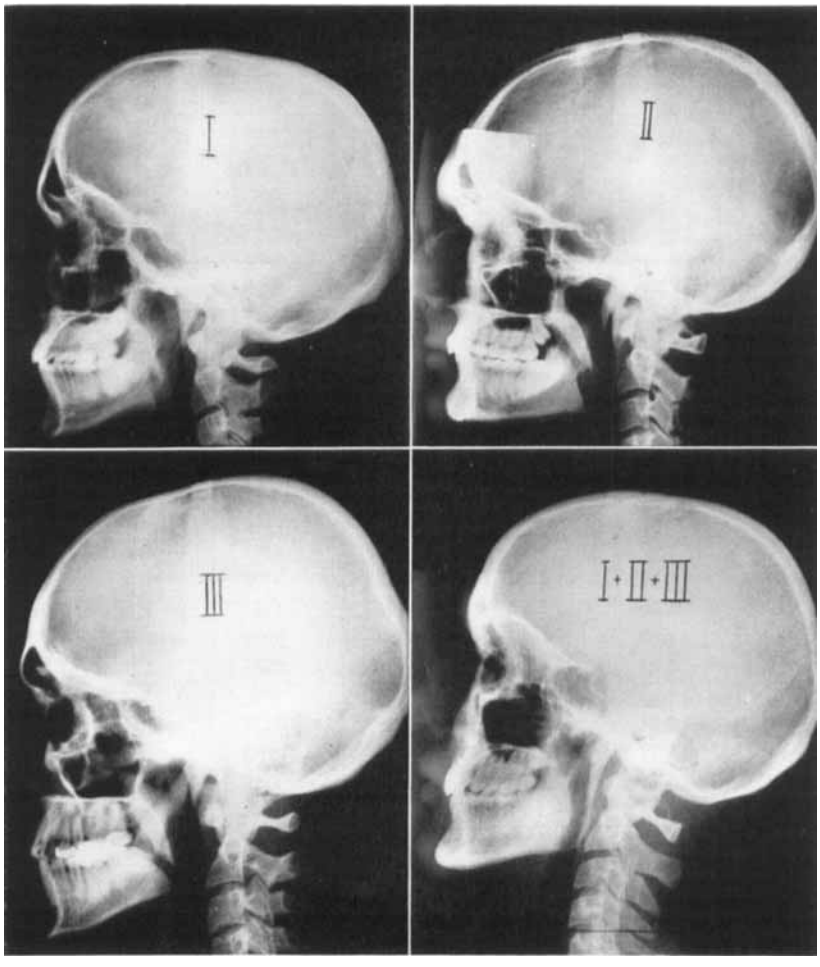


Fig. 13. Individual cases of lower third molar impaction from the dental student group associated with a single factor in mandibular development or with combination of all three factors: (I) small mandibular length, other factors normal, (II) large mandibular base angle, other factors normal, (III) alveolar retrognathy in the lower jaw, other factors normal, and (I + II + III) a case in which all three factors are combined.

vious impaction group. The vertical direction of condylar growth is of greatest significance to third molar impaction, followed by short mandibular length and then by reduced alveolar prognathy.

In order to analyse the effect of the individual combinations of the three skeletal factors we will then scrutinize Table XI in

the horizontal direction. The standard score of the added effect of the three factors in third molar impaction has been prepared in column 4, in a similar manner as in Table VIII. We reckon here, as previously, the deviations with a contributory effect to impaction as positive numbers, deviations with a counteracting effect as negative numbers, irrespective of sign. The effect of single factors as well as their combination is exemplified in Fig. 13.

The individual standard scores are positive in the majority of the cases and $\geqslant$ 1.0 in 24 cases (63 per cent). The average score is 1.4 standard units. The number of impaction cases which are accounted for by means of the combination of the three skeletal factors is thus 63 per cent, the limit being established at the standard score of 1. In the student group as well as in the previous material these percentage values should be regarded as merely descriptive and not as concrete characteristics of a population, because of the limited number of impaction cases.

The fourth factor, retarded mineralization of M_3, cannot be determined in this group.

Conclusions: The analysis of the ranking order of the factors in skeletal development of the mandible which concern third molar impaction shows that vertical direction of condylar growth (large β_2 angle) is the primary factor, followed by short jaw length and then by reduced alveolar prognathy.

The combination of these three skeletal factors obviously can account for about two-thirds of the individual cases of third molar impaction. These results fully corroborate the conclusions drawn from the first group, as described in Part II.

SUMMARY

The viewpoints advanced in this paper on the third molar impaction are based on a roentgenological examination of the third molar development in a total of 480 male individuals in two groups of approximately the same size.

The first group, the Swedish adolescent growth study group, comprises 243 individuals, and was examined at the age of 12 and 20. The second group comprises 237 Danish dental students

in the age interval from 19 to 30 years. The results from the longitudinal study of the first group and from the cross-sectional study of the second group are in full accordance, as far as they are comparable. In summary the results were as follows: —

1. Computations of the frequency of third molar impaction depend on the manner by which impactions are defined and, besides, depend on the age of the examined persons and on their dental condition as a whole. With the above reservations impaction of the mandibular M_3 may be expected in from every fourth to every fifth adult male in a Scandinavian population.

2. In cases of impaction of the mandibular third molar the alveolar arch space behind the second molar (M_3-space) is considerably reduced in 90 per cent of the cases, as evaluated from cephalometric profile roentgenograms.

3. The space for the mandibular third molar is found to be diminished when (1) the growth rate in length of the mandible is slight, (2) the direction of condylar growth is vertical or when (3) the eruption of the dentition is directed backwards. These three factors are separately influencing the third molar impaction. In individual cases they may either amplify or neutralize each other. The development in size of the mandible is evaluated as the length from chin to condylar head. The direction of condylar growth, which determines the shape of the mandible, is indicated by the mandibular base angle. Finally, the direction of the eruption of the mandibular dentition is determined by the degree of alveolar prognathy of the lower jaw.

4. An estimation of the ranking order of the three skeletal developmental factors in third molar impaction shows that vertical direction of condylar growth has the greatest effect, followed by small mandibular length and then by backward directed eruption of the dentition.

5. Furthermore, a relation has been found between impaction and retarded maturation of the mandibular third molar. Retarded maturation of M_3, or perhaps general retardation of dental development, constitutes the fourth factor of significance in the prognostication of third molar impaction.

6. The combination of the three factors in mandibular development should be considered in orthodontic treatment planning, as should also the degree of dental maturation.

RÉSUMÉ

CROISSANCE DU MAXILLAIRE INFÉRIEUR ET INCLUSION DE LA TROISIÈME MOLAIRE

L'éruption incomplète de la troisième molaire inférieure est un des problèmes majeurs de l'art dentaire en raison de sa fréquence et de ses implications cliniques.

Le manque d'éruption complète de la dent de sagesse du maxillaire inférieur est en général associé à un manque de place sur l'arcade alvéolaire. C'est pourquoi le manque de place a souvent été considéré comme la cause principale de l'inclusion, et cette opinion se trouve aussi confirmée dans cette étude.

La cause du manque de place dans la region de la troisième molaire inférieure, cependant, est une question qui n'a été étudiée que superficiellement. Le but des recherches présentes est de découvrir quels sont dans la croissance mandibulaire les facteurs essentiels qui ont une influence sur l'espace de la troisième molaire. Trois facteurs ont ainsi été définis dans cette étude, et l'on doit considérer qu'il est important pour le prognostic de les distinguer les uns des autres.

Les causes de l'éruption incomplète de la troisième molaire inférieure autres que la croissance mandibulaire ont aussi été examinées. Le retard de maturation de la troisième molaire apparait comme un quatrième facteur à considérer pour le prognostic.

Les points de vue émis ici sur l'inclusion de la troisième molaire sont basés sur un examen radiologique du développement de la troisième molaire chez en tout 480 sujets masculins répartis en deux groupes à peu près égaux en nombres.

Le premier groupe, le groupe suédois pour l'étude de la croissance adolescente, comprend 243 sujets qui ont été examinés à l'âge de 12 ans et à l'âge de 20 ans. Le second groupe comprend 237 étudiants danois en art dentaire d'âges compris entre 19 et 30 ans. Les résultats de l'étude longitudinale du premier groupe et de l'étude "cross-sectional" du deuxième groupe, montrent une concordance totale, dans la mesure où ils sont comparables. Un court résumé des résultats sera donné ci-dessous:

1. Les calculs sur la fréquence de l'inclusion de la troisième molaire dépendent de la manière dont on définit les inclusions,

et dépendent d'autre part de l'âge des personnes examinées et de leur état dentaire en général. Avec les réserves ci-dessus, l'inclusion de la troisième molaire inférieure peut être attendue chez un adulte homme sur quatre à un sur cinq dans une population Scandinave.

2. Dans les cas d'inclusion de la troisième molaire inférieure, la partie de l'arcade alvéolaire postérieure à la seconde molaire ("M_3-space") est considérablement réduite dans 90 % des cas, d'après des évaluations faites à l'aide de téléradiographies du profil.

3. La place pour la troisième molaire inférieure est trouvée diminuée quand (1) la croissance de la mandibule en longueur est faible, (2) la direction de la croissance condylienne est verticale, ou quand (3) l'éruption de la dentition est dirigée vers l'arrière. Ces trois facteurs influencent séparément l'inclusion de la troisième molaire. Dans les cas individuels ils peuvent réciproquement soit amplifier soit neutraliser leurs effets. Le développement de la mandibule en longueur est évalué au moyen de la distance du menton à la tête du condyle (cd-pgn). La direction de la croissance condylienne, qui détermine la forme de la mandibule, est estimée au moyen de l'angle de la base mandibulaire (β_2). Enfin, la direction de l'éruption de la dentition inférieure est estimée au moyen du développement de la prognathie alvéolaire du maxillaire inférieur (CL/ML_2).

4. Une évaluation de l'ordre de classement des trois facteurs du développement dans l'inclusion de la dent de sagesse montre qu'une direction verticale de croissance condylienne a l'effet le plus marqué, ensuite, une petite longueur mandibulaire, et en dernier lieu une éruption de la dentition dirigée vers l'arrière.

5. L'existence d'un rapport entre l'inclusion et le retard de maturation de la troisième molaire inférieure a en outre été prouvée. Le retard de maturation de la dent de sagesse, ou peut-être un retard général du développement dentaire, constitue le quatrième facteur significatif pour le pronostic de l'inclusion de la troisième molaire.

6. La combinaison des trois facteurs du développement de la mandibule devrait être prise en considération lors de l'élaboration du plan de traitement orthodontique, ainsi que le degré de maturation dentaire.

ZUSAMMENFASSUNG

WACHSTUM DER MANDIBULA UND IMPAKTIERUNG DES DRITTEN MOLAREN

Der unvollständige Durchbruch des dritten Molaren im Unterkiefer ist wegen seines häufigen Auftretens und seiner klinischen Konsequenzen eines der wichtigsten Probleme der Zahnheilkunde.

Mangelhafter Durchbruch des unteren Weisheitszahnes findet sich gewöhnlich in Verbindung mit Raummangel im Alveolarfortsatz. Raummangel ist deswegen als Hauptursache der Impaktierung angenommen worden; eine Beobachtung, die auch durch diese Arbeit bestätigt wird.

Die Ursache des unzulänglichen Raumes in der Region des dritten unteren Molaren ist jedoch eine Frage, die nur oberflächlich untersucht worden ist. Der Zweck dieser Arbeit ist es, die wesentlichen Faktoren des Unterkieferwachstums, die den Raum für den Weisheitszahn beeinflussen, zu finden. Drei solcher Faktoren sind durch die Untersuchungen näher definiert worden und es muss im Hinblick auf die Prognose Wert darauf gelegt werden, diese von einander zu unterscheiden.

Andere Ursachen für den mangelhaften Durchbruch des unteren Weisheitszahnes, abgesehen vom Wachstum des Unterkiefers, sind ebenfalls erforscht worden. So ist die verspätete Reifung des dritten Molaren als vierter Faktor zu bezeichnen und als solcher bei der Stellung der Prognose zu berücksichtigen.

Die Gesichtspunkte, die hier vertreten werden hinsichtlich der Impaktierung des dritten Molaren, gründen sich auf eine röntgenologische Untersuchung der Entwicklung des dritten Molaren bei 480 männlichen Individuen, die zwei Gruppen ungefähr gleicher Grösse angehören.

Die erste, die schwedische adolescente Wachstumsuntersuchungsgruppe, welche 243 Individuen umfasst, wurde sowohl im Alter von 12 als auch im Alter von 20 Jahren untersucht. Die zweite Gruppe umfasst 237 dänische Studenten der Zahnheilkunde im Alter von 19 bis 30 Jahren. Die Resultate der "longitudinal" Untersuchung der ersten Gruppe und der "cross-sectional" Untersuchung der zweiten Gruppe stimmen völlig über-

ein, soweit es möglich ist, diese zu vergleichen. Eine kurze Zusammenfassung der Resultate folgt unten.

1. Die Frequenzberechnungen über Weisheitszahnimpaktierungen sind abhängig von der Art und Weise, wie die Impaktierung definiert worden ist, ferner vom Alter und von den Bissverhältnissen der untersuchten Individuen. Unter Wertung dieser Vorbehalte kann man bei jedem vierten bis fünften erwachsenen männlichen Individuum der skandinavischen Bevölkerung eine Impaktierung des dritten Molaren im Unterkiefer erwarten.

2. Bei Impaktierungen des dritten Unterkiefermolaren ist der Raum im Alveolarfortsatz hinter dem zweiten Molaren (M_3-space), der nach cephalometrischen Profilröntgenaufnahmen beurteilt ist, in 90 % der Fälle stark reduziert.

3. Der Raum für den dritten Unterkiefermolaren wird vermindert sein, wenn (1) das Längenwachstum der Mandibula gering, (2) die Wachstumsrichtung des Kondylus vertikal gerichtet ist oder wenn (3) die Durchbruchsrichtung der Zähne rückwärts zielt. Diese drei Faktoren beeinflussen — jeder für sich — die Impaktierung des dritten Molaren. Individuell gesehen können sie entweder ihre Wirkung gegenseitig verstärken oder abschwächen. Aus dem Abstand Kinnprominenz — Kiefergelenkköpfchen lässt sich die Grössenentwicklung des Unterkiefers beurteilen (cd-pgn). Die Wachstumsrichtung des Kondylus, die die Form der Mandibula bestimmt, wird vom mandibulären Basiswinkel aus festgestellt (β_2). Ferner lässt sich die Durchbruchsrichtung der Zähne im Unterkiefer aus der Entwicklung der alveolaren Prognathie schätzen (CL/ML_2).

4. Eine Beurteilung der Rangordnung der drei Entwicklungsfaktoren bei Weisheitszahnimpaktierung im Unterkiefer zeigt, dass die vertikale Wachstumsrichtung des Kondylus von grösster Wirkung ist, während eine geringe Länge der Mandibula und ein rückwärts gerichteter Durchbruch der Zähne als zweit- bzw. drittrangig anzusehen sind.

5. Man hat ferner eine Verbindung zwischen Weisheitszahnimpaktierung und verspätete Reifung des dritten Unterkiefermolaren nachgewiesen. Verspätete Reifung dieses Zahnes, vielleicht eine allgemein verspätete dentale Entwicklung, kann hin-

sichtlich der dritten Molarenimpaktierung prognostisch ein vierter Faktor von Bedeutung sein.

6. Bei der Planlegung der orthodontischen Behandlung müssen diese drei Entwicklungsfaktoren des Unterkiefers in ihrer Gesamtheit gemeinsam mit dem Ausmass der dentalen Reifung berücksichtigt werden.

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