The Relationship Between Third Molar Agenesis And The Morphologic Variability Of The Molar Teeth

HARRIS J. KEENE, D.D.S.
U. S. Navy

Third molar agenesis occurs with variable frequency in different human populations.[1-5] Although most studies of the third molar (M_3) have been singularly concerned with its absence, impaction, size or morphology, recent investigations have shown that M_3 agenesis should not be considered merely as an isolated anomaly. Garn and associates[6-10] reported an increase in the incidence of other missing teeth, tooth size reduction, differences in P_2M_2/M_2P_2 eruption order and a delay in posterior tooth formation associated with M_3 agenesis. Keene[11] observed more spacing and less crowding of the teeth and a three percent reduction in mean mesiodistal diameter of the lower first molar in caries resistant naval recruits with M_3 agenesis.

In addition to diminished tooth size, one might theoretically expect to find other evidence of reduction in the molars such as loss of cusps when third molars are congenitally missing. The present study is concerned with the relationship between third molar agenesis and the morphologic variability of the molar teeth as reflected by cusp number.

MATERIALS AND METHODS

The material available for analysis consisted of the artificial stone casts made from alginate impressions of the upper and lower dental arches of 257 white male naval recruits 17 to 25 years of age (mean age, 18 years). All of the men had completely negative histories of dental caries as determined clinically and roentgenographically and were participants in the Great Lakes Caries-Immune Program. This group, which comprises approximately 0.2 per cent of the total recruit population, has been described previously.[11,12]

The morphology of all the molar teeth as observed on the casts was studied and each molar was classified according to the number of cusps present. No attempt was made to classify the associated groove patterns. Molars which had not completely erupted were not considered. The absence of dental caries and restorations in the study group greatly facilitated the analysis of the models; however, the cusp-number classification was not completely without complication.

For example, the hypocone or distolingual cusp of the maxillary molars presented a wide display of reduction forms which could be subdivided into several groups according to size, morphology and groove pattern. For this study, whenever a definite distolingual cusp or cuspule was noted, it was regarded as contributing to the total cusp number regardless of size.

In a small number of cases the hypoconulid or distal cusp of the mandibular molars exhibited a tendency to be divided by a shallow groove into two smaller cuspules. Some authors[13,14] have referred to the lingual half of this structure as a sixth cusp, or the *Tuberculum*

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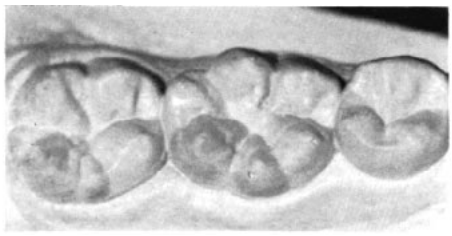

Figure 1 An example of a 6-cusped mandibular left first molar with an X-shaped groove pattern. The extra cusp is located between the metaconid and the entoconid. The anomalous structure appeared in a small number of men with no third molar agenesis.

accessorium posterius internum. This variation was not considered an extra cusp in the present classification, but the two smaller structures, when present, were counted as a single cusp, the hypoconulid.

The mandibular first molar occasionally displayed an extra cusp located between the two lingual cusps which resulted in an X-shaped groove pattern (Figure 1). This type, which was classified in the present study as a 6-cusped molar, is described by Selenka[14] who refers to the extra cusp as the *Tuberculum accessorium medium internum.*

The classification of Carabelli's cusp has always been somewhat of a problem, and many proposals[15] have been made, each with its own merit. For the purposes of this study, a simplified classification was made similar to that used by Meredith and Hixon[16] in which no actual measurements were taken. The categories used for the present study are described as follows:

Category A There is no evidence of any type of cusp, groove, or pit on the lingual surface of the mesiolingual cusp. The lingual surface is smooth.

Category B There is a slight pit, shallow groove or slight depression on the lingual surface of the mesiolingual cusp. The markings are variable and they are distinct but there is no evidence of cuspal elevation.

Category C There is a slight elevation projecting from the lingual surface of the mesiolingual cusp accompanied by a definite U-shaped groove which demarcates the small cuspule from the body of the cusp.

Category D There is a moderate elevation projecting from the lingual surface of the mesiolingual cusp accompanied by a definite U-shaped groove which demarcates the moderately developed cuspule from the body of the cusp.

Category E There is a large elevation projecting from the lingual surface of the mesiolingual cusp accompanied by a definite U-shaped groove which demarcates the large cuspule from the body of the cusp. This type (Figure 2) was considered a "major" cusp in the cusp number classification and was the basis for placing some of the maxillary molars in a "5-cusp" category.

In the above classification types A, C, D, and E would approximate Dahlberg's Class A, F, G, and H respectively.[17] His classes B, C, D, and E were combined into our Class B.

Results

Seventy men (27 per cent) had agenesis of one or more third molars as confirmed by intraoral roentgenographic examination. The anatomical distribu-

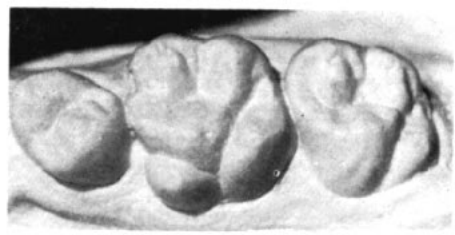

Figure 2 A maxillary left first molar with a large Carabelli cusp (Type E). The frequency and size of this variable trait were reduced when third molar agenesis occurred and when the adjacent second molar had only three cusps.

Table 1

Anatomical Distribution and Frequency of Third Molar Agenesis

M_3 Agenesis (Max./Mand.)	Number of men	Per cent
0/0	187	72.8
1/0	11	4.3
0/1	13	5.1
1/1	5	1.9
2/0	5	1.9
0/2	10	3.9
2/1	4	1.6
1/2	5	1.9
2/2	17	6.6
Total	257	100.0

tion and frequency of M_3 agenesis are shown in Table one. A total of 159 third molars were congenitally missing; the mandible accounted for 54 per cent, the maxilla 46 per cent. All four third molars were congenitally missing in 17 men (6.6 per cent). Only 113 third molars had erupted sufficiently for morphological classification. The remaining third molars were either impacted, unerupted or incompletely developed.

In the group with one or more M_3 agenesis, 7.5 per cent of the men had other congenitally missing teeth such as maxillary lateral incisors or second bicuspids; in the group with no M_3 agenesis, only 1.6 per cent were similarly affected. This is in agreement with the findings of other investigators[6] who reported an increased incidence of congenitally missing teeth of other morphologic classes when third molar agenesis occurred.

The data on cusp number distribution for the entire group of 257 men is shown in Table 2. The order of variability for the maxillary molars was $M_3 > M_2 > M_1$ with the first molar showing the most stability. The diminishing stability from anterior to posterior which appeared in the upper molars was not as clearly defined in the lower molars which varied in the following order: $M_3 > M_1 > M_2$. The mandibular first molar appeared to be morphologically less stable than the second molar due to its frequent departure from the usual 5-cusp pattern to the 4-cusp form (17 per cent). In the maxilla as well as in the mandible,

Table 2

Frequency Distribution of Molar Cusp Forms

Tooth	Number of teeth	Frequency (per cent) 3 cusp	4 cusp	5 cusp	6 cusp	Total
Maxilla						
M_1	514	1.0	96.5	2.5*	0	100.0
M_2	510	40.6	59.4	0	0	100.0
M_3	75	82.7	17.3	0	0	100.0
Mandible						
M_1	514	0	16.9	81.5	1.6**	100.0
M_2	509	0	93.5	6.5	0	100.0
M_3	49	0	59.2	40.8	0	100.0

*In a small number of cases a large Carabelli cusp on the maxillary first molar was considered a major cusp. (See Fig. 2).

**There were 8 first molars which had an "extra"cusp located between the two lingual cusps. (See Fig. 1).

Table 3

The Relationship Between Third Molar Agenesis in the Maxilla and Maxillary Molar Cusp Number

Maxillary Molar	Number of Cusps	187 Men with no M_3 Agenesis: Number of Teeth	Percent	44 Men with 1 or 2 Max. M_3 Agenesis: Number of Teeth	Percent
M_1	3	3	0.8	2	2.3
	4	360	96.3	84	95.4
	5*	11	2.9	2	2.3
TOTAL		374	100.0	88	100.0
M_2	3	140	37.8	45	51.1
	4	230	62.2	43	48.9
TOTAL		370**	100.0	88	100.0

*Maxillary first molars with a large Carabelli cusp (Class E) were placed in the "5 cusp" category (Figure 2).

**There were four maxillary second molars which had not erupted sufficiently for morphologic classification.

Table 4

The Relationship Between Third Molar Agenesis in the Mandible and Mandibular Molar Cusp Number

Mandibular Molar	Number of Cusps	187 Men with no M_3 Agenesis: Number of Teeth	Percent	54 Men with 1 or 2 Mand. M_3 Agenesis: Number of Teeth	Percent
M_1	4	57	15.2	27	25.0
	5	309	82.6	81	75.0
	6*	8	2.2	0	0
TOTAL		374	100.0	108	100.0
M_2	4	344	93.0	102	95.3
	5	26	7.0	5	4.7
TOTAL		370**	100.0	107**	100.0

*Mandibular first molars with an extra cusp located between the two lingual cusps were placed in the "6 cusp" category (Figure 1).

**A total of five mandibular second molars had not erupted sufficiently for morphologic classification.

Table 5

The Relationship Between Maxillary Third Molar Agenesis and the Incidence and Degree of Development of Carabelli's Cusp on the Maxillary First Molar

Carabelli Classification	187 Men with no M_3 Agenesis		44 Men with 1 or 2 Max. M_3 Agenesis	
	Number of Max. M_1	Per Cent	Number of Max. M_1	Per Cent
A	149	39.8	43	48.8
B	124	33.2	34	38.6
C	59	15.8	7	8.0
D	31	8.3	2	2.3
E	11	2.9	2	2.3
TOTAL	374	100.0	88	100.0

The classification of Carabelli's cusp ranged from "None" (A) to "Large" (E). Analysis of the above distribution when classes A and B were compared with classes C, D, and E yielded a chi-squared value of 8.115, $(0.01 > P > 0.001)$.

the third molars were the least stable morphologically due to the cusp number and agenesis polymorphisms.

The relationship between third molar agenesis and molar cusp number is shown in Tables 3 and 4. When M_3 agenesis occurred in the maxilla, the most noticeable change occurred in the second molar which showed a 13 per cent increase of 3-cusp forms (no distolingual cusp) and a corresponding decrease in 4-cusp forms $(0.05>P>0.02)$. The lower second molar remained relatively stable morphologically in the presence of M_3 agenesis, retaining its 4-cusp form in most of the cases. The theoretically stable 5-cusped lower first molar[18] showed a 10 per cent increase in the number of 4-cusp forms when M_3 agenesis occurred $(P<0.05)$. Of additional interest was the observation that when M_3 agenesis occurred, no 6-cusped lower first molars were seen, although these unusual forms (Figure 1) were found in a small percentage of the men with no M_3 agenesis.

It has been suggested that the incidence and degree of development of Carabelli's cusp is largely independent of the number of cusps in the maxillary molars.[19] It was, therefore, of interest to determine what influence third molar agenesis may have on the expression of this variable structure on the maxillary molars.

The relationship between third molar agenesis and the incidence and degree of development of Carabelli's cusp is shown in Table 5. Only the results for the first molar are given due to the lack of expression of this cusp on the other molars. In the few cases in which the Carabelli trait was found on a second molar, it was also expressed on the adjacent first molar, but in a more highly developed form. A type C Carabelli cusp was seen on two of the erupted maxillary third molars; however, it was not found on any of the adjacent molars in these two cases.

As can be seen in Table 5, the morphological variability of the Carabelli trait in the maxillary first molars was partly related to the presence or absence of third molar agenesis. The cusp was expressed more strongly and more frequently when there was no M_3 agenesis. Caribelli types C, D, and E, in which a definite elevated cusp or cuspule was present, appeared more than twice as frequently on the first molar when there was no M_3 agenesis $(0.01>P>0.001)$.

The variability of the Carabelli trait

Table 6

The Relationship Between Maxillary Second Molar Cusp Number and the Incidence and Degree of Development of Carabelli's Cusp on the Maxillary First Molar

Carabelli Class.	No. Cusps (Max. M_2)	First Molar Frequency N.	%
A	3	128	61.2
	4	81	38.8
B	3	64	36.0
	4	114	64.0
C	3	14	17.9
	4	64	82.1
D	3	1	3.1
	4	31	96.9
E	3	0	0
	4	13	100.0

The classification of Carabelli's cusp ranged from "None" (A) to "Large" (E).

Analysis of the above distribution when classes A and B were compared with classes C, D, and E yielded a chi-squared value of 54.122 ($P < 0.0001$). The ratio of 3 and 4-cusped second molars in the entire group was 2:3.

on the first molar also appeared to be related to the number of cusps present on the adjacent second molar. This relationship can be seen in Table 6. The normal ratio of 3-cusped to 4-cusped second molars in the present material was 2:3. This ratio should theoretically remain the same if M_2 cusp number and the Carabelli trait are not related. However, when the larger Carabelli categories were combined (type C, D, and E), there was an excess of 4-cusped second molars, almost 5 times as many as would be expected from the normal ratio ($P<0.0001$).

Discussion

Third molar agenesis has recently been described by Garn, Lewis, and Vicinus[20] as a "key to the tooth polymorphism puzzle" in which variations in tooth number, tooth size, eruption sequence, and calcification timing are all interlocking parts. The data in the present report suggest that, in addition, third molar agenesis may be related to morphologic variability of the molar teeth as reflected by cusp number. In the presence of M_3 agenesis the evidence points strongly to reduction of the hypoconulid of the mandibular first molar, the hypocone of the maxillary second molar, and the Carabelli cusp of the maxillary first molar. The intensity of expression of the Carabelli trait also appears to be partly related to the number of cusps on the adjacent second molar.

The loss of molar cusps in the presence of third molar agenesis was not completely an unexpected finding. Tooth size reduction has been reported by many investigators,[10,11,21,22,23] and Dahlberg[24] has demonstrated the relationship between tooth size and cusp number. The unexpected finding was the lack of stability of mandibular M_1 as compared with M_2. The lower second molar remained essentially a 4-cusped tooth in most of the cases; however, M_1 showed a definite tendency for cusp reduction in the presence of M_3 agenesis. In the present material there were no 3-cusped lower second molars; however, one man with agenesis of both lower third molars had bilateral second molars with greatly reduced distolingual cusps, almost giving a tricuspid appearance. His lower first molars were of the reduced, 4-cusp form. Mandibular second molars with reduced distolingual cusps have been described by Dahlberg.[25]

In a different group of 138 naval recruits,[26] all with confirmed agenesis of both mandibular third molars, five men (4 per cent) had 3- cusped lower second molars (bilateral in 4 men), the distolingual cusp or entoconid apparently being the reduced structure (Figure 3). One man had a 3-cusped lower

Figure 3 An example of morphologic simplification in the mandibular teeth of a man with agenesis of both lower third molars and both lower second bicuspids. The deciduous second molars were retained. Note absence of the hypoconulid on the first permanent molar, absence of the hypoconulid and the entoconid on the second permanent molar, and the caniniform first bicuspid.

first molar; the other first molar and the adjacent second molar had four cusps. It was apparent from this limited sample that even the supposedly stable first molar[18] is subject to considerable morphologic variation. The variability of this tooth has been described recently by Schulze[27] who also cites an example of the 3-cusped lower first molar in a case of partial anodontia as well as many other morphologic variations. The study of a larger series of men, however, would be required to define more clearly the relationship of M_3 agenesis to cusp reduction.

If we accept the formula $\frac{4-4-4}{5-5-5}$ for the molar cusp pattern of ancient man,[28] it then appears that the variability of the maxillary molars in the present study diminishes from posterior to anterior with M_1 being most stable. This is in accordance with the expected reduction pattern as postulated from Butler's[29] "field concept". The lower molars generally exhibit the expected reduction pattern also with M_1 remaining essentially a 5-cusped tooth and M_2 having 4 cusps. The lower third molar, however, presents somewhat of an enigma, although unquestionably it is the most variable of the lower molars. The problem arises with the occurrence of 5-cusped third molars in the presence of 4-cusped second molars and occasionally 4-cusped first molars. In theory, the teeth anterior to the variable third molar (M_1 and M_2) should not exhibit reduction unless the third molar itself is reduced. The findings in the present study are somewhat at variance with the "field concept", for in many cases M_3 appeared to be more stable morphologically than either M_1 or M_2. Dahlberg[17,30] and Frisch[31] have also cited certain morphologic traits in the dentition which are not completely in agreement with "field concept" theory.

Only 49 mandibular third molars in the present material had erupted sufficiently for measurement and classification. Approximately 25 per cent were larger mesiodistally than either M_1 or M_2 and in these cases they usually had 5 well-developed cusps. Nanda and Chawla[32] also noted the tendency for many human third molars to have larger mesiodistal diameters than the first or second molars. The molar size formulas of Paranthropus $\frac{(M_1<M_2<M_3)}{M_1<M_2<M_3}$ and Australopithecus $\frac{(M_2>M_3>M_1)}{M_1<M_2>M_3}$ suggest a similar relationship to some extent.[33]

Tooth morphology and size are of additional interest from the dental caries-nutritional status point of view. Several investigators[34-36] have described various alterations in morphology such as loss of cusps, reduced size, and elimination of grooves or fissures under various experimental conditions, or in association with differences in caries susceptibility. Of special interest was the report by Shiller[36] who found a tendency for "caries immune" naval recruits to exhibit less cusp reduction than caries susceptibles. No mention of third molar agenesis frequency in either group was made; however, a small excess of

men with this anomaly in the caries susceptible group could have possibly accounted for some of the differences noted. This points to the necessity of considering M_3 agenesis in different populations along with the reporting of morphological differences associated with caries susceptibility.

Summary

The relationship between third molar agenesis and molar cusp number variability was studied in 257 white male naval recruits with caries-free histories. Twenty-seven per cent of the men exhibited agenesis of one or more third molars. The frequency of congenitally missing teeth of other morphologic classes was higher in the group with one or more M_3 agenesis than in those with no M_3 agenesis.

In the presence of third molar agenesis the remaining molars exhibited a tendency towards morphological simplification as evidenced by loss of or reduction in size of certain cusps. In the mandible the cusp most subject to reduction was the hypoconulid of the first molar; in the maxilla, the hypocone of the second molar was most variable.

The frequency and intensity of expression of Carabelli's cusp on the maxillary first molar also appeared to be related to the presence or absence of third molar agenesis. Both the frequency and size of this variable trait were reduced when M_3 agenesis occurred, or when the adjacent second molar had only three cusps.

The order of morphological variability for the maxillary molars was $M_3>M_2>M_1$; for the mandibular molars the order of variability was $M_3>M_1>M_2$. The unexpected morphological instability of the mandibular first molar was partly due to absence of the hypoconulid in cases where M_3 agenesis occurred.

First Marine Brigade,
F.P.O. San Francisco.

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