The Frequencies of Accessory Tubercles and Other Traits in the Upper Deciduous Second Molar

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Abstract Small irregular cuspules or tubercles are often seen on the occlusal table of the human deciduous molar as well as the permanent molar. These frequencies were investigated semi-quantitatively with the use of moiré contourography. The moiré photographs of the occlusal surface were taken with the tips of the paracone, protocone and metacone aligned in a horizontal plane parallel to the grating of the moiré contourography. Contour interval was set at 0.2 mm. The frequency of occurrence of a tubercle was counted in three grades according to its contour patterns. Materials were Japanese deciduous upper second molars of 23 males and 33 females with negligible attrition. The frequencies of appearance of tubercles were as follows (sexes pooled): (1) mesial paracone tubercle, 62.5%; (2) mesial accessory tubercle, 19.6%; (3) protoconule, 19.6%; (4) lingual paracone tubercle, 87.5%; (5) metaconule, 26.8%; (6) distal accessory tubercle, 14.3%; (7) CARABELLI's cusp, 82.1%; (8) buccostyle, 17.8%. The incidence of the traits was compared with those in the permanent first molars previously studied. The traits nos. 4, 5, 7 and 8 were significantly more frequent in the deciduous molars than in the permanent first molar, when tested by $\chi^2$ test. On the other hand, the traits nos. 1, 2, 3 and 6 which located on the mesial and distal marginal ridge did not show significant difference between both molars. This suggested that there might have been differences of phylogenetical origins between traits on the marginal ridge and those in the occlusal table and/or on buccal and lingual surfaces.

Key Words: Deciduous upper molar, Anomalous cusp, Moiré contourography. Three-dimensional measurement

Introduction

The frequencies of non-metrical traits in the deciduous molar crown have been studied by several authors to compare them with those of the permanent molars (Hanihara, 1956a, b; Korenhof, 1982), to investigate their population differences (Jørgensen, 1956: Hanihara, 1976; Grine, 1990), to understand their phylogenetical relationships with the original...
characters (von Koenigswald, 1967) and to analyze synapomorphy in taxonomical study of human fossil materials (Grine, 1985). In spite of the accumulation of knowledge on morphological traits in deciduous dentition by these studies, there is still a difficulty in comparing these data because of different standards of observation which each study has adopted.

We carried out the investigation on the frequency of appearance of irregular tubercles in the deciduous lower molar occlusal table using a semi-quantitative method, i.e., the moiré contourography (Kanazawa et al., 1992). The results, compared with those of the permanent lower first molar studied by the same method, revealed that tubercles around the metaconid of the deciduous second molar showed considerable variability.

The present study is a subsequent investigation of the frequencies of accessory tubercles which appeared on the upper deciduous first molar. The results were also compared with those of the permanent molar. Morphological and phylogenetical significance of the tubercles in both the deciduous and permanent dentition was also discussed.

**Materials and Methods**

Materials used were casts of deciduous maxillary second molars from Japanese children, 23 males and 33 females. Some of the teeth were attrition-free, but the rest exhibited slight wear under microscopic observation. They were from the right side of dentition except when this tooth was lost or severely damaged.

Each dental stone cast of a molar was set in the position of the standard tricuspal plane (Korenhof, 1960; Ozaki et al., 1977) with the cusp tips of the protocone, paracone and metacone parallel to the horizontal grating of the moiré grid and perpendicular to the axis of the lens. The camera used was a Nikon F-2 with a Micro-Nikkor 105-mm lens and PN-11 close-up ring. The contour interval was set at 0.200 mm between the first and the second moiré fringe. The film used was Kodak TMAX developed at ISO 1600. Photography was accomplished in a dark room with f/32 at 0.5 second of exposure. The size of a tubercle was expressed in three grades, i.e., 0.5, 1.0, and over 1.5, representing the number of contour lines counted. The scoring method for the traits was previously reported in detail (Kanazawa et al., 1992).

The tubercles examined were as follows: 1) Mesial paracone tubercle (MPT). This tubercle appears on the mesial marginal ridge as an independent part of the mesial accessory ridge of the paracone. 2) Mesial accessory tubercle (MAT). This occurs also at the mesial marginal ridge, in a typical case, exactly mesial to the mesial groove. However, the distinction of this tubercle from MPT may sometimes be difficult. 3) Protoconule (PRT). This is the mesial accessory ridge of the protocone grown to an independent cusp which is frequently separated from the main cusp of protocone by a shallow groove running from mesiolingual surface to the occlusal table. 4) Lingual paracone tubercle (LPT). This tubercle appears in mesiolingual side of the central ridge of the paracone, located just buccally to the mesial groove. Morphological continuation of this tubercle to MPT or MAT is frequently found. 5) Metaconule (MET). A small tubercle may occur on the oblique ridge or exactly on the central ridge of the metacone. 6) Distal accessory tubercle (DAT). This tubercle is usually called Cusp 5, which appears on the distal marginal ridge between the metacone and hypocone. 7) Carabelli's cusp (CAR). A fairly large tubercle appearing on the lingual side of the protocone. This can be observed from the occlusal aspect. 8) Buccostyle (BUS). A delicate swelling with a pit on the buccal side of the paracone (Korenhof, 1960). The examples of
these eight traits are shown in Figs. 1 and 2.

The last two traits, CARABELLI’s cusp and buccostyle, are differently scored from the others. When the contour lines on the buccal or lingual surface are waved or distorted, the score 0.5 was given. When there is an independent circle on the top of the trait, the score 1.0 was given.

The differences of the frequencies of tubercles between deciduous and permanent molars were tested by the $\chi^2$ test using a two way table (SOKAL and ROHLF, 1981).

Table 1 shows the frequencies of tubercles in three grades both in males and in females. The LPT has the highest frequency both in males and in females. The larger numbers of the second and third grade of this tubercle than that of the first grade indicate that the traits is well-developed. The frequency of the CARABELLI’s cusp is also

Table 1. Frequencies of the tubercles appearing on the occlusal table of the deciduous upper second molar

|                | Male (N = 23) | Female (N = 33) |
|----------------|---------------|-----------------|
|                | Present (0.5 1.0 1.5<) | Absent | Present (0.5 1.0 1.5<) | Absent |
| 1. Mesial Paracone Tubercle | 13 (8 5 0) | 10 | 22 (12 10 0) | 11 |
| 2. Mesial Accessory Tubercle | 16 (5 10 1) | 7 | 27 (12 14 1) | 6 |
| 3. Protocone | 3 (1 1 1) | 20 | 8 (5 3 0) | 25 |
| 4. Lingual Paracone Tubercle | 20 (6 7 7) | 3 | 29 (7 12 10) | 4 |
| 5. Metacone | 5 (3 2 0) | 18 | 10 (9 1 0) | 23 |
| 6. Distal Accessory Tubercle | 2 (0 1 1) | 21 | 6 (2 2 2) | 27 |
| 7. CARABELLI’s Cusp | 19 (15 4 0) | 4 | 27 (22 5 0) | 6 |
| 8. Buccostyle | 3 (3 0 0) | 20 | 7 (7 0 0) | 26 |
Table 2. Frequencies in the pooled samples and the comparison with those of the upper permanent first molar

|                        | Deciduous (N = 56) | Present | %   | Permanent (N = 56) | Present | %   |
|------------------------|--------------------|---------|-----|--------------------|---------|-----|
| 1. Mesial Paracone Tubercle | 35                 | (62.5)  |     | 36                 | (64.3)  |     |
| 2. Mesial Accessory Tubercle | 43                 | (76.8)  |     | 37                 | (66.1)  |     |
| 3. Protoconule          | 11                 | (19.6)  |     | 11                 | (19.6)  |     |
| 4. Lingual Paracone Tubercle | 49 **              | (87.5)  |     | 22                 | (39.3)  |     |
| 5. Metaconule           | 15 **              | (26.8)  |     | 3                  | (5.4)   |     |
| 6. Distal Accessory Tubercle | 8                 | (14.3)  |     | 17                 | (30.3)  |     |
| 7. CARABELLI’s Cusp     | 46 **              | (82.1)  |     | 18                 | (32.1)  |     |
| 8. Buccostyle           | 10 **              | (17.8)  |     | 0                  | (0.0)   |     |

Asterisks denote significant difference of the frequency by $\chi^2$ test at the 1% level of probability. Frequencies of the traits in the permanent dentition were cited from KANAZAWA et al., 1990.

relatively high, but that of the second grade is low. This indicates that the cusp rarely protrudes much in the occlusal direction. The second grade of MAT is the highest among the traits, but the frequency of the third grade is low. The frequencies of the protoconule, metaconule and DAT are relatively low. There were no significant differences (5% probability) in the frequency of all the tubercles and grades between the male and the female.

Table 2 shows the frequencies of the tubercles when the sexes were pooled. The frequencies in the permanent first molar (KANAZAWA et al., 1990) are also presented for comparison. There were significant differences in the frequency of four tubercles (LPT, metaconule, CARABELLI’s cusp and buccostyle) between the deciduous and permanent molar. No significant differences were found in the incidence of tubercles on the mesial or distal marginal ridge.

The test for associations between traits was carried out based on $2 \times 2$ contingency analysis. However, there are no significant correlations between any pair of traits at the 5% level of significance.

Discussion

The morphological traits characteristically observed on the occlusal surface of the deciduous maxillary second molar are different from those in the permanent first molar. For example, the buccostyle, scarcely found in the permanent dentition, is observed fairly frequently in the deciduous dentition. It is generally accepted that the deciduous molars have more primitive characters than the permanent molars (HANIHARA, 1956a, b; von KOENIGSWALD, 1967). The morphologies of dentino-enamel junction (DEJ) are also said to be morphologically conservative (SAKAI and HANAMURA, 1971). Because enamel substance is thinner in the deciduous teeth than in the permanent teeth, these conservative characters of the DEJ might be reflected more clearly in the deciduous teeth (FINN, 1973). In the permanent dentition, on the other hand, where enamel deposition is much thicker, the minute topographic changes along the DEJ could be hidden. CHRISTENSEN (1967) studied human molar tooth buds obtained from 71 human fetuses and concluded that small tubercles on the DEJ appeared to lose their
association of the CARABELLI’s cusp with other traits in the deciduous molar, the considerably higher frequency of this cusp in the deciduous second molar than in the permanent first molar suggests that the deciduous second molar is not reduced and accompanies other phylogenetically primitive characters compared with the permanent first molar.

Associations of the incidence between dental traits were studied by several authors (SAKAI and HANAMURA, 1971; BERRY, 1976; SCOTT, 1978). Of these traits, CARABELLI’s cusp in the permanent molar is reported to associate with the cingular nodule of the maxillary second incisor (BERRY, 1976), with the protostylid of the lower first molar (SCOTT, 1978) and with the mesial tubercle (LPT in the present study) (SAKAI and HANAMURA, 1971). Although these associations were not found in the present study, we are uncertain whether it is due to the small sample size or to the sample itself which was not the permanent, but deciduous second molar.

There is a slight swelling accompanying a shallow groove on the buccal surface of the deciduous molar paracone. The name of this trait adopted in this study is the buccostyle. WEIDENREICH (1937) found this trait on the Sinanthropus permanent molar and called it the “half moon-shaped arcade” which is originated from cingulum. He also stated that it was never found in the permanent molar of the recent man. HANIHARA (1956a, b) observed this trait in 18.8% of the deciduous second molars in Japanese children. He thought that this trait represented WEIDENREICH’s description and that it might have an origin similar to that of the protostylid and CARABELLI’s cusp. KORENHOF (1960) described a “tuberculum paramolare” which appeared in upper permanent M2 and M3. He did not mention the deciduous molars, but his description of “type a” of this tubercle as “... the cusp is bordered by a more or less distinct semilunar groove” may represent the tubercle now in discussion. He gave the term “buccostyle” to this trait. His nomenclature is based on that the tubercle is derived from the buccal cingulum without being homologous with the parastyle.

Four traits located on the mesial and distal marginal ridges did not show differences in frequency between deciduous and permanent teeth. HANIHARA (1956b) reported the high frequency of the protoconule (88.8%) in the deciduous second molar, but similar results were not obtained in this study. Our result (19.6%) is just the same as those of the permanent molar previously studied by us using the same method (KANAZAWA et al., 1990). The protoconule usually occurs on the mesial occlusal surface of the protocone with a shallow groove on the mesiolingual surface. In modern humans, this cusp seems to be an independence of the mesial accessory ridge of the protocone from the central ridge. This morphology is different from that of metaconule or LPT which appears as if it were put on the enamel surface. On the other hand, the protoconule is observed as the separation of a mesial part of the protocone. The groove on mesiolingual surface of the protocone is quite frequently found in the deciduous second molar which might have been counted as protoconule in HANIHARA’s investigation. As our study is based on the assessment of the occlusal contour pattern, the difference of results between HANIHARA’s and ours may be ascribable to these different methods.

The information recorded here suggests that minor traits on the crown of the deciduous maxillary second molar may exhibit the differences of phylogenetical origins between traits on the marginal ridges and those in the occlusal table and/or on buccal and lingual surfaces. The phylogenetical origin of the traits on the marginal ridges cannot be traced to those in primitive
identity as appositional growth occurred. SAKAI and HANAMURA (1971) also reported that some molars had the CARABELLI's cusp on DEJ without the appearance of the trait on the enamel occlusal surface.

Of those characters showing a difference in frequency between the deciduous and permanent dentition, the lingual paracone tubercle (LPT) had the highest frequency in the deciduous second molar (87.5%). This tubercle usually shows a frequency around 40% in the permanent dentitions, but some populations show a different incidence of this tubercle (e.g., Australian Aboriginals, 78%) (KANAZAWA et al., 1990). HANIHARA (1956b) suggested that this tubercle might be homologous to the crista transversa observed in the maxillary molar of fossil hominoids and anthropoid apes. SAKAI and HANAMURA (1971) observed this tubercle on the permanent DEJ and found that the swelling of DEJ at this point is weaker than that on the enamel surface, but it is still conspicuously demarcated from the surrounding surface. In the maxillary first molar of Sivapithecus (GREGORY et al., 1938), the crista transversa anterior clearly extends from paracone to protoconule suggesting a close relationship between protoconule and LPT. However, the modern human LPT usually has a round or ovoid shape continuing to the marginal tubercles, MPT or MAT, having no direct connection to the protoconule.

The fully developed metaconule is rarely found in the permanent dentition yielding no population difference in the incidence of this trait (KANAZAWA et al., 1990). SEKIKAWA et al. (1990) suggested that the deciduous molars with metaconules had larger intercuspal distance than molars without metaconules. As a result, the development of the metaconule might be related to the enamel thickness at its position.

CARABELLI's cusp is also a trait observed more often on the deciduous molar than on the permanent one. It has been said that there are considerable differences of the incidence of CARABELLI's cusp among world-wide populations (SCOTT, 1980). According to KORENHOF (1960), the origin of CARABELLI's cusp is a lingual cingulum represented by Adapis magnus (Lemur). SAKAI and HANAMURA (1971) also studied the phylogenetical origin of this trait and stated that it is derived from Periconodon in the Eocene, and progressively developed in modern humans via Sivapithecus and Dryopithecus in the Miocene. Their findings are supported by the fact that this trait is incidentally observed in some kinds of living primates (COLYER, 1936; KORENHOF, 1960; FRISCH, 1965; KINZEY, 1973), although the distribution of the frequency among primates has not been studied yet.

CARABELLI's cusp is still a controversial topic in dental anthropology. Although the mode of inheritance of this cusp is not fully understood, there does seem to be a relationship between the existence of this cusp and the tooth size. REID et al. (1991) recently found that the crown base areas of the upper M1 were larger in trait-positive than in trait-negative molars. SCOTT (1979) reported that the size of the CARABELLI's cusp and that of the hypocone were consistently associated on both the first and second permanent molars, and concluded that the reduction of the CARABELLI's cusp paralleled the reduction of other maxillary molar characteristics.

The size of the hypocone is largest in the permanent first molar in the molar series among almost all the human populations. This tooth has also high frequency of the CARABELLI's cusp in Caucasians, which may represent the parallel trend of occurrence of these two cusps in evolutionary sense. However, the parallel association of these traits are not seen in Mongoloid populations, because the frequency of the CARABELLI's cusp in this tooth appears to be reduced.

Although there is no data available on the
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primates except for the protoconule, while others can be traced back, e.g., to the crista transversa anterior, metaconule, protostyle and parastyle in primitive mammals. Further studies such as morphologies of dentino-enamel junction of deciduous molars or accumulation of fossil evidences will be needed to characterize ontogenetical and phylogenetical conditions of these minor traits.

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