Open Bite And Thumb Sucking In Rhesus Monkeys

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One of the earliest self-induced malocclusions detectable in children is the anterior open bite associated with nonnutritive sucking habits. This subject has been widely investigated and discussed by pediatricians, psychologists, pedodontists, orthodontists and, of course, by the parents. Many different causes have been recognized and numerous contradictory remedies have been proposed from brutal interference of the habit in the infant to late orthodontic correction in the early teens. Few studies have, however, investigated this problem quantitatively. This, in part, is due to the difficulty of studying infants under controlled conditions. The present preliminary study reports the development, under laboratory conditions, of anterior open bite in the deciduous dentition of rhesus monkeys (Macaca mulatta), associated with nonnutritive sucking habits.

REVIEW OF LITERATURE

There is vast literature concerning thumb sucking and open bite in man, much of which is not directly connected with the present study; a few reviews are those written by Massler and Wood ('49), Jarabak ('59), Decoster ('36), and Brash, et al. ('56); all contain excellent bibliographies.

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Some studies more pertinent to the present investigation are:

Swinehart ('38) described the mechanical forces involved in thumb sucking: 1) the passive force of the thumb against the arch, 2) the abnormal contraction of the cheeks against the side of the arch by the sucking action, and 3) the abnormal muscular pressure of the thumb against the palate. To these forces, Strang ('50) adds the production of a vacuum in the oral cavity by sucking action.

Johnson ('39) found that malocclusion of the deciduous dentition may correct itself after the thumb sucking habit has been broken, if normal lip function exists; if not, in all probability the malocclusion persists.

Teuscher ('40) states that the abnormal forces of the cheek musculature operating against the posterior teeth cause narrowing of the dental arches. Jarabak ('59) goes further stating that posterior crossbite may result from adverse muscular forces associated with thumb sucking.

Sillman ('51) found, on the other hand, that if thumb sucking displaces anterior teeth, it does not seem to affect the molar relation.

The only reports to our knowledge referring to open bite associated with thumb sucking in the rhesus monkey have been described by:

Kelsey ('36) who observed one monkey with pronounced anterior open bite induced by a constant finger-sucking habit still present at four and one-half years of age.

Smith ('60), in a psychology thesis, University of Wisconsin, wrote on non-

nutritive sucking habits among infant rhesus monkeys. She reports the presence of anterior open bite in several monkeys due to sucking habits. She found that nonnutritive sucking habits were more prevalent in bottle-raised than cup-raised monkeys and also more frequent in male than in female monkeys.

Statement of the Problem

From this brief review of the literature it becomes evident that a controlled study pertaining to this problem is necessary. There is enough evidence to indicate that this subject has wide clinical importance. What is the effect of nonnutritive sucking habits on dental occlusion? What are the associated effects on the facial skeleton? Is the information derived from rhesus monkeys applicable to man? These are a few of the questions which we shall attempt to answer in this preliminary report.

Present Study

The total sample includes forty-seven rhesus monkeys, divided into three series.

1. *The Cayo Santiago Series* composed of five free-ranging monkeys living on Cayo Santiago Island, Puerto Rico. Chronological age unknown. Dental age: complete deciduous dentition. Three males and two females.

2. *The Bluffton Series* consists of thirty-three skulls of wild-born monkeys from India who died from intestinal diseases at Bluffton, S.C. and were prepared at Charleston, S.C. Chronological age unknown. Dental age: complete deciduous dentition and/or first permanent molars. Sex unknown.

3. *The Fort Johnson Series.* These monkeys were born and raised at Charleston, S.C. The colony was established by Dr. James A. Gavan to investigate the growth and development of the normal rhesus monkey. Nine monkeys have been born from known parents, three females and six males. They have been followed since birth and constitute our laboratory series. In this study they all have a deciduous dentition with age ranging from six to ten months.

In the laboratory at Charleston the neonatal monkey is separated from its mother at birth and raised independently. This offers maximum control over the monkey's environment. Upon removal from the mother the infant is weighed, checked for deciduous teeth, x-rays of the hand and teeth taken and, when possible, anthropometric measurements obtained. The milk used for feeding is made from a prepared powdered food formula for infants. The animals are fed with the Brecht feeder, as used for premature human infants. Feeding is thus under the control of the operator and, when necessary, the milk may be expressed to elicit sucking and swallowing reflexes in the neonate.

For the first few days the infant does little if any actual sucking; the nipple must be placed on the lips, and the milk simply drains or is expressed into the mouth where it is swallowed. After this initial period of behavior, the baby monkey usually takes the nipple in its mouth and actively sucks, although it tires frequently and must rest. It would appear, therefore, that the amount of sucking is quite variable.

During the first week some ten to twenty minutes are required for each feeding. Hand feeding is continued during the second week, but, in addition, a bottle is placed on the front of the cage in a readily accessible position. In this manner, the young monkey may augment its diet independent of any schedule. Also, during the second week small pieces of orange and banana are placed in the animal's cage. Hand feeding is terminated at the end of the second week. For the next two weeks

the monkey receives a cage bottle, and, at the end of the first month, a synthetic diet is made available morning and evening. After sixty days the milk formula is discontinued and the infant is then on a synthetic diet supplemented with oranges, bananas, onions, etc.

A few points which are relevant to this study may now be summarized. The infant monkey is bottle fed seven times a day for the first week of its life. Each feeding requires from 10 to 20 minutes; therefore, in a period of 24 hours an infant is "sucking" food from 70 to 140 minutes. In other words, an infant monkey spends from around 5% to 10% of a 24 hour period nursing during the first week of its life. Thereafter, a cage bottle is added and it is impossible with our present laboratory facilities to make a quantitative assessment of nursing time. The bottle is there and the infant monkey may take frequent trips to the nipple during the next two months. We do not know if 5% to 10% of every day spent in nursing during the first week is too little or too much time spent in this activity. The first few days of nursing usually require very little vigorous sucking on the part of the infant monkey.

Fort Johnson monkeys have been observed with their thumbs in their mouths a few hours after birth. All of these animals, with the exception of one female, suck thumbs, fingers, or big toes and the same monkey may indulge in the habit with any of these three body parts. This nonnutritive sucking occupies much of their time when not being fed although it is impossible to quantify this information. We can state empirically, therefore, that eight out of nine monkeys have been persistent nonnutritive suckers during the acquisition of their deciduous dentition.

The Normal Rhesus Monkey

Open bite has been found associated with endocrine imbalance, systemic diseases and aberrant growth and development (Seipel, et al. 1952; Anderson, et al. 1952). In order to be sure that, in our laboratory sample, thumb sucking and open bite are correlated we have to exclude the above factors. Therefore, routine examinations have been performed to ascertain the normality of the Fort Johnson colony (the same examinations are routinely taken on the Cayo Santiago monkeys).

1. Growth and Development

The biologic status of the animals was evaluated by roentgenograms of the hand. X-rays at birth and six months show our monkeys align closely with the schedule published by van Wagenen and Asling ('58) but are advanced over the averages published by Gisler, et al. ('60).

The eruption of the deciduous dentition of rhesus monkeys has been studied by Hurme and van Wagenen ('53). We found that the Fort Johnson monkeys erupt their teeth earlier than their animals, in fact about 0.7 standard deviations earlier.

The average sitting height of our monkeys compared with the data of van Wagenen and Catchpole ('56), shows no significant difference at the ±5% confidence limit. Weight averages between these two samples fall within the ±5% limit of confidence.

Our hematological studies reveal no significantly different leucocyte counts between the Fort Johnson animals and the published material of Krise ('60). Sedimentation rates are generally believed to indicate the health of an animal, (Sauer and Fegley, 1960). These authors state, "From the results, it is our interpretation that a monkey with a sedimentation rate of less than 2mm/hour could be considered, for most intents and purposes, as healthy". Sedimentation rates of our monkeys reveal

that none of them ever showed a sedimentation rate approaching 2mm/hour. However, all of these results should be interpreted with caution.

It would appear, therefore, that the Fort Johnson monkeys are healthy animals, which, to date, have suffered no severe retardations or interruptions during their developmental period. In fact, there are indications that our monkeys may be slightly accelerated in their growth and development.

2. Premaxillary-Maxillary Complex

The premaxillary bone consists of a body and two processes, a nasomaxillary and a palatine process. The bone is wedged between the two maxillas inferiorly and the inferolateral border of the nasal bone in the median portion of the upper jaw superiorly. The medial boundaries of the premaxillary bones form the greater part of the pyriform aperture with the nasal bone completing the opening along the superior border. The premaxillary elements contain the deciduous incisors and later their permanent successors.

The premaxillary suture remains patent in the rhesus monkey for several years after birth. The only statement concerning the obliteration of this suture in nonhuman primates found in the literature was in the comprehensive paper by Ashley-Montagu ('35) on the premaxilla in primates. In 539 skulls, ranging in age from infant to adult (ages based on tooth eruption), he found the suture completely obliterated in only 10.1% of all specimens. In the Bluffton skull series we were unable to locate a single case where the premaxillary suture was completely obliterated. This is further substantiation for the protracted separation of the maxillary-premaxillary complex in macaque monkeys.

3. Incisors.

The next important structures involved in open bite are the incisors. In the normal rhesus monkey the lingual surfaces of the maxillary incisors overlap the labial surfaces of the mandibular incisors. This slight overbite appears to be characteristic of rhesus with the complete deciduous dentition, although Baume and Becks ('50) report that in progressively older animals there is a shift to an edge-to-edge bite of the incisors.

The edge-to-edge relation of the incisors is common in older rhesus monkeys, but it is by no means the representative pattern in these animals. Instead, very often the slight labial overlap of the maxillary incisors is maintained, and there develops in time a bevel or step on the lingual surfaces of these teeth. This lingual step may be present on either the deciduous or permanent maxillary incisors; it is usually better developed on the central incisors. Baume and Becks note the formation of this lingual step and attribute it to the progressive decrease in the coronal length of the upper incisors.

Methods

Dental models were made of the Fort Johnson and Cayo Santiago series. The measurements of these two series were taken from the dental casts while those of the Bluffton series were taken directly from the skulls. The caliper points were sharpened to make measuring as accurate as possible. Dental arch breadths and lengths of the maxilla were taken in the following manner:

a. The bicanine width, between the crown tips of the canine teeth.
b. The bimolar diameter, the greatest distance between the buccal surfaces of the second deciduous molars.
c. Dental arch length, the distance between the tangent to the labial surfaces of the deciduous central incisors and a plane tangent to the distal sur-

faces of the second deciduous molars, perpendicular to the occlusal plane.

d. Anterior arch length is the distance between the tangent to the labial surfaces of the deciduous central incisors and a plane through the bicanine breadth perpendicular to the occlusal surface. This dimension corresponds to the anteroposterior length of the premaxillary bone.

e. Posterior arch length is the distance between the tangent to the distal surfaces of the second deciduous molars and a plane through the bicanine breadth perpendicular to the occlusal surface.

Several additional measurements were taken in order to gain a clearer picture of anterior open bite. These were taken as follows:

f. Open bite (i^2-i_2) is the vertical distance from the incisal edges of the maxillary lateral incisors to the incisal edges of the mandibular lateral incisors with the teeth in occlusion. The measurement is taken in a line parallel to the maxillary incisal edges and, in cases of horizontal overjet, the horizontal distance between the maxillary and mandibular incisal edges is projected.

g. Open bite (i^1-i_1) is taken in the same manner as in (f) except it is between the maxillary and mandibular central incisors.

h. Horizontal overjet is the horizontal distance between the labial surface of the mandibular left central incisor and the incisal edge of the maxillary left central incisor in a plane parallel to the occlusal surfaces of the deciduous molars with the teeth in occlusion.

i. Overbite is measured as in Moorrees ('59) except the distance is taken on both the central and lateral incisors. It is the distance from the incisal edges of the mandibular incisors to a point on their labial surfaces, denoting the projection of the incisal edges of the maxillary incisors in a plane parallel to the occlusal surfaces of the deciduous molars with the teeth in occlusion.

j. Spacing is measured as the distance between the lateral incisor and the canine (i^2-c) on both right and left sides. If additional spacing was noted between other teeth it was measured, but since this was seldom encountered, tabulations were not made at this time.

Findings

1. *General*

None of the animals in the Cayo Santiago and Bluffton series had an anterior open bite. In contrast to the free-ranging groups, eight out of nine Fort Johnson monkeys presented an anterior open bite. All the monkeys with open bite have been observed to be inveterate thumb and/or toe suckers since birth. The ninth animal without open bite has been observed only on rare occasions to indulge in sucking habits. This animal was not incorporated in the open bite sample for statistical treatment.

2. *Open bite*

The measurements described above were taken on forty-seven animals. Mean values and standard deviations were calculated for each series (Table I).

There is an average of 2.4 mm of overjet in the Fort Johnson series as compared to an upper and lower incisor contact in all the animals of the two other series.

The open bite is more pronounced in the upper central (2.0 mm and 1.78 mm) than in the lateral incisors (.41 mm and .17mm). These cases are illustrated in Fig. 1. Some of the diagrams show that only a unilateral open bite is

TABLE I

OPEN OVERBITE

Dimension	N	Mean	Range	S.D.
Horizontal Overjet	8	2.40	+1.0 +4.0	1.18
Open Bite Rt. (i_2-i^2)	8	.41	—0.7 +1.8	.59
Open Bite Rt. (i_1-i^1)	8	1.78	—0.3 +4.2	1.14
Open Bite Lt. (i_2-i^2)	8	.17	—1.4 +1.0	.63
Open Bite Lt. (i_1-i^1)	8	2.00	+1.0 +3.7	.27

TABLE II

DENTAL ARCH LENGTHS AND BREADTHS

Fort Johnson

Dimension	N	Mean	Range	S.D
Bicanine (c-c)	8	17.9	17.0-18.5	.50
Arch Br. (dm_2-dm_2)	8	25.3	24.0-28.0	1.19
Arch Lg. (dm_2-i_1)	8	24.8	23.0-27.0	1.36
Ant. Arch Lg. (c-i_1)	8	10.8	9.5-12.0	1.00
Post. Arch Lg. (dm_2-c)	8	13.8	13.0-14.5	.22
Space Rt. (i_2-c)	8	2.9	2.0- 4.0	.58
Space Lt. (i_2-)	8	2.6	2.0- 3.5	.58

Bluffton skulls

Dimension	N	Mean	Range	S.D
Bicanine (c-c)	33	18.3	16.5-20.0	.96
Arch Br. (dm_2-dm_2)	33	26.3	24.0-28.5	1.20
Arch Lg. (dm_2-i_1)	33	23.1	20.0-25.5	1.44
Ant. Arch Lg. (c-i_1)	33	9.1	7.0-11.5	.94
Post. Arch Lg. (dm_2-c)	33	13.8	12.0-15.5	.95
Space Rt. (i_2-c)	31	2.5	1.5- 4.5	.66
Space Lt. (i_2-)	31	2.6	1.5- 3.6	.57

Cayo Santiago

Dimension	N	Mean	Range	S.D
Bicanine (c-c)	5	19.2	17.5-20.0	1.04
Arch Br. (dm_2-dm_2)	5	26.7	24.0-28.0	1.57
Arch Lg. (dm_2-i_1)	5	24.6	23.0-26.5	1.30
Ant. Arch Lg. (c-i_1)	5	9.7	9.0-10.5	.67
Post. Arch Lg. (dm_2-c)	5	14.6	13.5-16.0	.96
Space Rt. (i_2-c)	5	2.5	1.5- 4.0	1.00
Space Lt. (i_2-)	5	2.5	1.5- 4.0	1.00

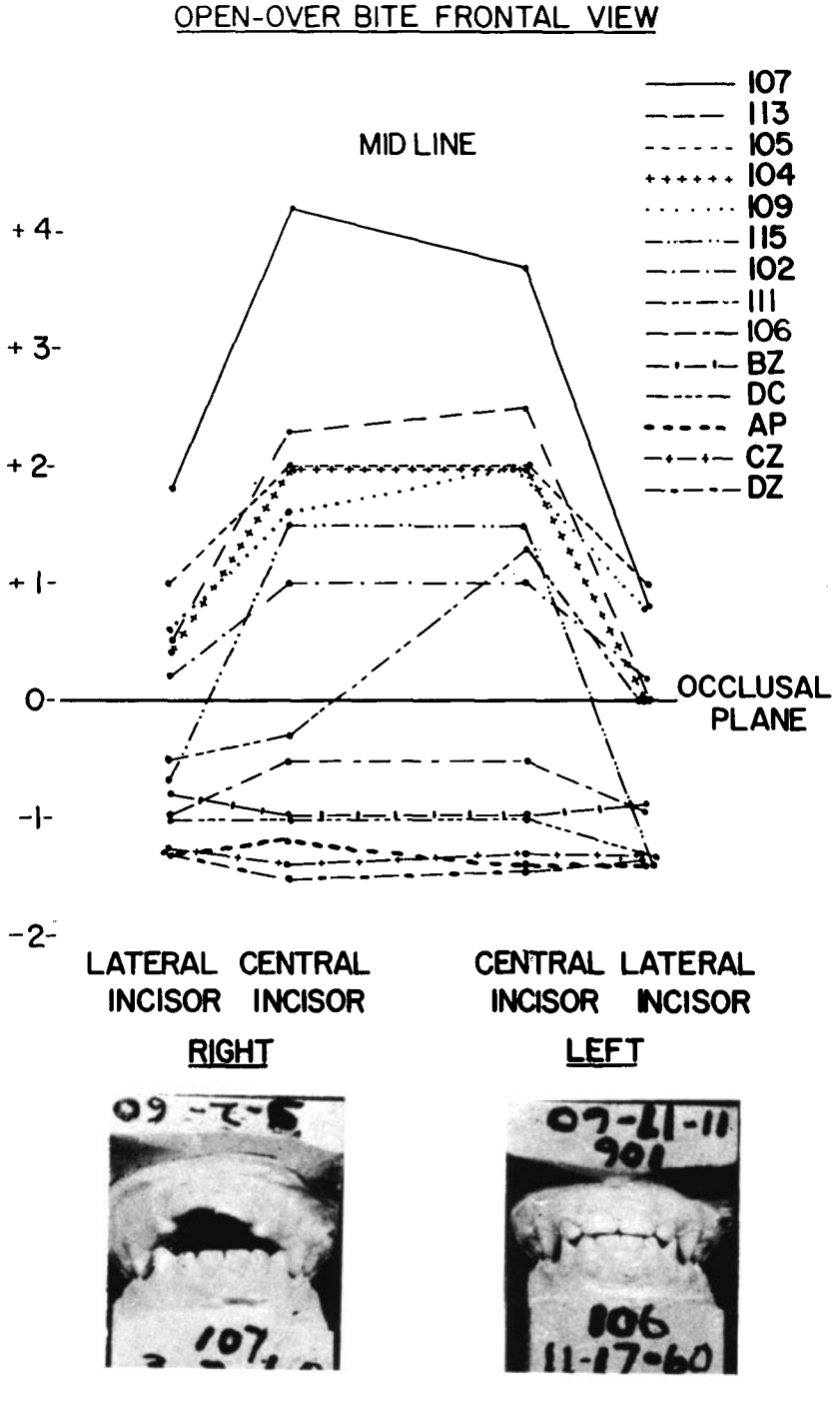

Fig. 1

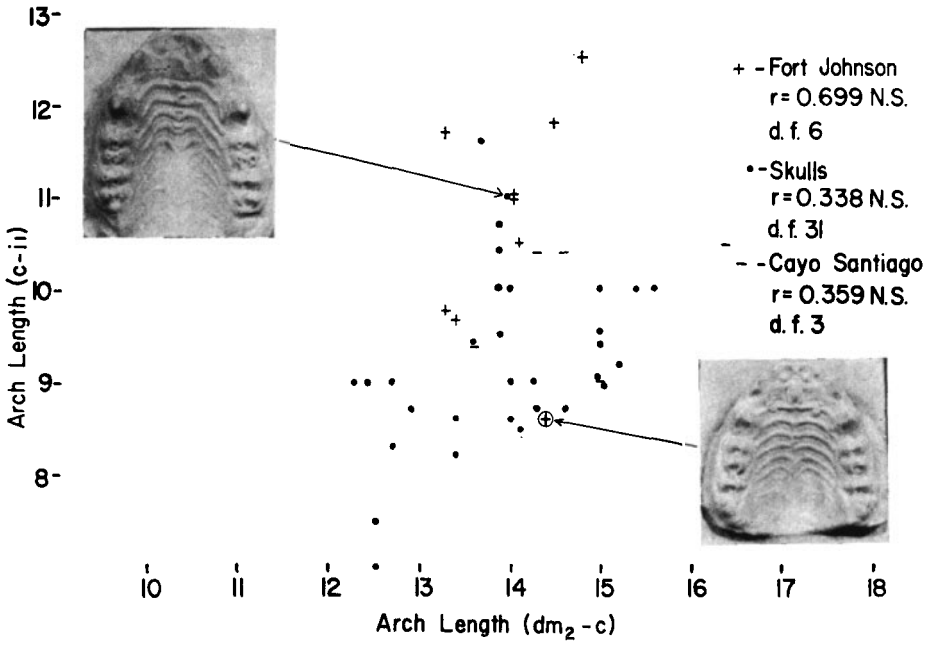

Fig. 2

present. All five rhesus monkeys from Cayo Santiago present some degree of overbite and are represented below the occlusal plane level.

3. *Effect of thumb sucking on maxillary dental arch.*

Arch lengths and breadths were calculated in the three series (Table II).

None of the measurements show a significant difference between the three samples. However, three measurements show a common trend: In the open bite series the bicanine breadth is narrower; the bimolar breadth is narrower, and the anterior arch is longer than in the two other groups.

The space between the lateral deciduous incisors and canines of both sides is slightly greater (2.9 mm and 2.6 mm in the Fort Johnson monkeys) than in the other two series (Table II). Although not tabulated, spacing does occur between the lateral and central incisors in some Fort Johnson monkeys and a central diastema is present in four out of the eight animals. This type of spacing is not seen in the Bluffton and Cayo Santiago animals.

4. *Relationship between premaxillary* and *maxillary.*

The palate was divided into two segments. The anterior segment ($c\text{-}i_1$) corresponds to the premaxillary bone while the posterior portion ($dm_2\text{-}c$) includes the region of the palatine process of the maxilla. Coefficients of correlations calculated from the dimensions taken of these two segments do not differ significantly from zero, indicating that these two areas are independent. (Fig. 2). It may be interesting to note that No. 106, the non-thumb-sucking monkey, is more closely associated with the group of wild born animals than with the thumb sucking group as far as these two segments of the palate are concerned. Although only a single case, it illustrates further the effect of thumb sucking.

Discussion

The Fort Johnson colony has been demonstrated as composed of biologically normal rhesus monkeys. No other detectable cause of the open bite was found except thumb and toe sucking habits. It may be surprising to find such a pronounced open bite at this young age (6-10 months old). However, it should be remembered that the rhesus monkey erupts its incisors within about a week after birth, while in humans the delayed eruption (6 months average) does not expose the maxilla to the influences of sucking habits until much later.

As to the cause of the sucking habit itself, we cannot pin-point a specific factor (bottle feeding, early removal from mother, captivity, emotional disturbance, fatigue); however, we should mention that very few young rhesus monkeys observed under wild conditions were seen sucking their thumbs (Chandler, 1960). Protracted thumb sucking may, therefore, have some connection with captive life and its artificial environmental living conditions.

The primate space between the upper lateral incisor and canine shows a slight increase. Spacing between other anterior teeth, especially the presence of the central diastema, is very infrequent in wild living monkeys. Baume and Becks ('50) report a primate space of about 2 mm with all the other deciduous teeth in contact. We interpret these spaces as the consequence of nonnutritive sucking habits probably augmented by tongue action associated with anterior open bite.

Although our computations are not conclusive, a narrowing of the maxillary dental arch and an elongation of the premaxillary dental arch appear to develop with thumb sucking. Our data suggests an independence between the premaxillary and maxillary segments of the palate. However, our measurements have been taken on teeth of the dental arch and it is quite possible that the differences found reflect only tooth movement but no real skeletal changes. In order to obtain more precise information roentgenographic cephalometric films and occlusion films are now taken on the animals.

Moore ('49) presented an excellent discussion of head growth in the rhesus monkey as revealed by alizarin red S injection. Among his numerous findings were several statements germane to the present study. In describing the growth of the face he noted, "The most striking area of the face was the premaxilla. This bone is separate in the monkey at this age and apparently enjoys a prolific, independent growth. The suture separating it from the maxilla was sharply defined indicating no growth of the adjacent surface of that bone". He used one female rhesus monkey with a "dental age comparable to a 5-year-old human being". This would indicate the monkey's age to have been between one and one half and two years. Since we have shown that the premaxillary suture remains open for several years and in view of Moore's work, we might also assume that it remains an active area of independent growth.

None of the open-bite monkeys presented a posterior malocclusion. Observers of humans have reported that thumb sucking may be the cause of a Class II malocclusion because of a mesial pull on the whole maxillary arch and/or by preventing the mandible growing forward. In the rhesus monkey the anatomy of the teeth and arches may have prevented this from happening. The relatively deeper grooves and higher cusps create a locked interdigitation between upper and lower buccal segments, thus preventing mesial drift. In addition, the premaxillary-maxillary suture, situated between the canine and

lateral incisor, may be active into adulthood in monkeys while it is closed very early in life in man. This may be a reason why a force applied on the premaxilla of the monkey may not necessarily be transmitted to the maxilla. The suture may have a limiting effect.

With the longitudinal study actually in progress we expect to reach a more definite explanation of these phenomena. In addition, we expect to follow the development of the open bite toward either self-correction or permanent stabilization.

Summary

This study reports the association between thumb sucking and the development of dental anterior open bite in the deciduous dentition of forty-seven rhesus monkeys. Nine of these were laboratory born, while thirty-eight were wild born. Dental arch measurements were taken on all animals.

1. Eight of the nine laboratory animals manifested thumb-toe sucking habits and developed an anterior open bite. None of the wild born monkeys had an open bite.

2. The open bite is more accentuated at the central incisors than at the lateral segments.

3. There is some indication that there may be a narrowing and lengthening of the dental arch in the thumb-sucking group.

4. Aberrant spacing is present between the upper anterior teeth.

5. The data suggest the independence between premaxillary and maxillary segments.

This is a preliminary report. Longitudinal data are in process of being accumulated to provide information about the end result of the present open bite (self-correction or stabilization of malocclusion).

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