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ORIGINAL ARTICLES

OBSERVATIONS ON THE FORM OF THE DENTAL ARCH OF THE ORANG*

BY MILO HELLMAN, D.D.S., NEW YORK CITY.

THE prevailing notion regarding the conformation of the dental arch of the anthropoid ape appears to be so thoroughly settled in the minds of many scientists that it would seem an imposition for any one to attempt a reiteration of facts so widely known and generally accepted. Superposing this thought with the idea that what is contained in the present contribution is somewhat at variance with what has hitherto been advanced, it becomes a rather delicate task for one who considers himself not fully qualified to speak authoritatively on the subject of anthropology. It is, therefore, my intention to submit these observations with a feeling of reserve, confining myself to a description of the actual facts observed and claiming no epoch-making discoveries in the endeavor to contribute something that may aid in the correction of some of the numerous errors that befog our views in the perception of the truth.

Especially, is it necessary now to rouse no undue expectations by advancing any theories or making final deductions, as this is but the beginning of an investigation which will extend through the entire anthropoid family, when, with more extensive data on hand and more matured judgment, it will be reasonable to expect some definite conclusions.

The present task involves a description of the phenomena observed in connection with the form of the dental arch of the orang, omitting all attempts of any interpretations, but aiming mainly to answer the following questions:

1. Does the dental arch of the orang conform to the outline as described by various authorities?
2. Is the "diastema" in the orang dentition a phenomenon similar to that appearing in some lower forms?

*Read at the meeting of the New York Academy of Sciences held in May, 1917, at the American Museum of Natural History, New York, N. Y.

3. Is the labidonty or edge-to-edge bite an exclusively pithecoïd characteristic?

1. DOES THE DENTAL ARCH OF THE ORANG CONFORM TO THE OUTLINE DESCRIBED BY VARIOUS AUTHORITIES?

Tomes, De Terra, Selenka, and various other authorities concur with the idea that the dental arch form of "the most anthropomorphous apes" differs from that of man, in that "the teeth instead of being arranged in a sweeping curve, the jaws are squarish, the incisors being arranged in something approaching a straight line between the outstanding canines, behind which the premolar and molar series run in straight lines, converging somewhat as they go backward." (Tomes.)

On the examination of the collection numbering eighty-three orang skulls at the National Museum, Washington, D. C., comprising those gathered by W. L. Abbott, the outlines assumed by the dental arches in this ape were found to conform to five different configurations, these forms being determined mainly by the mode of arrangement of the premolar-molar series. The incisors and canines in all these forms coincide with Gregory's description, as forming "an evenly rounded or arched series." The outlines to which the dental arches were found to conform may conveniently be described as follows (see Table I):

Pyriform	U-shaped	Divergent	O-shaped	Saddle-Shaped

36	54	24	17	27

Table I.—Table showing the various forms which the dental arches in the orang assume and frequency of their occurrence. For the sake of simplicity the figures representing these forms will hereafter be referred to by letters. Thus, pyriform, P; U-shaped, U; divergent, D; O-shaped, O; and saddle-shaped, S.

1. The pyriform arch, in which the widest dimensions are in the first premolar region, thereafter the buccal teeth, arranged in straight or nearly straight lines, converge posteriorly. (Fig. 1-A and B.)

2. The U-shaped arch, in which the premolar-molar series are arranged in straight lines parallel to each other. (Fig. 2-A.)

3. The diverging arch, in which the premolar-molar series are arranged in straight or nearly straight lines diverging as they proceed backward. (Figs. 3-A and B, 4-B.)

4. The O-shaped or oval arch, in which the premolar-molar series are arranged in curved lines with the convexity toward the cheek. (Fig. 4-A) and

5. The saddle-shaped arch, in which the premolar-molar series are arranged in curves with the convexity toward the tongue. (Fig. 5-A and B, and Fig. 2-B.)

The general outline of these forms though perceptible to the eye, on visual observation, were, nevertheless, determined by accurate measurements taken as follows: The width between the two sides of the mouth was obtained by measuring the distance between the premolar-molar series of either side using the cusps of the teeth in the lower jaw and the fossæ of the teeth in the upper, as starting points; thus in the lower jaw the distances between the two sides of the premolar-molar series were measured at the cusp points of the buccal cusps of the pre-

A.

B.

Fig. 1.—Occlusal view of upper (A) and lower (B) jaws of male orang showing pyriform type of dental arches. X $\frac{1}{16}$.

A.

B.

Fig. 2.—Occlusal view of upper (A) and lower (B) jaws of male orang showing U-shaped upper and saddle-shaped lower dental arches of the same animal.

molars, and the cusp points of the disto-buccal cusps of the molars. In the upper the measurements were taken between the depressions in the occlusal surfaces of the premolars and molars accomodating the cusp points mentioned of the lower teeth.

These forms though exhibited by both the upper as well as the lower dental

*A.**B.*

Fig. 3.—Occlusal view of upper (*A*) and lower (*B*) jaws of female orang showing the divergent form in both dental arches.

A. *B.*

Fig. 4.—Occlusal view of upper (*A*) and lower (*B*) jaws of female orang showing O-shaped form in the upper and the divergent in the lower dental arch of the same animal.

A. *B.*

Fig. 5.—Occlusal view of upper (*A*) and lower (*B*) jaws of male orang showing the saddle-shape in both the upper and lower dental arches, the upper being somewhat less accentuated than the lower.

arches are not necessarily found to be alike in both jaws of the same individual. They may appear in harmonious relationship, as in Figs. 1, 3, and 5, but more often the two dental arches of one individual are independent in form, as in Figs. 2 and 4. Table II shows the frequency with which these forms appear in the upper and lower jaws.

TABLE II

FREQUENCY WITH WHICH THE VARIOUS ARCH FORMS APPEAR IN THE UPPER AND LOWER JAWS*

Form of Dental Arch	P	U	D	O	S
Upper	32	24	9	17	1
Lower	4	30	15	0	26

*The letters in the top row indicate the form of arch, thus: P, pyriform; U, U-shaped; D, divergent; O, O-shaped; and S, saddle-shaped.

Thus, it may be deduced from Table II that while the pyriform arch appears in the upper jaw in the proportion of 8:1 as compared with its frequency in the lower, the O-shaped arch is exclusively prevalent in the upper. The U-shaped arch, on the other hand, is about equally divided between the two jaws, while the saddle-shaped arch is almost entirely confined to the lower, the divergent type being in the proportion of 5:3 in favor of the lower.

TABLE III

DISTRIBUTION AND FREQUENCY OF THE VARIOUS ARCH FORMS AS THEY APPEAR IN THE TWO SEXES*

Form	P		U		D		O		S	
Sex	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Upper	24	8	14	9	1	8	2	15	1	0
Lower	4	0	15	15	5	9	0	0	17	10

*The letters in the top row indicate the forms as follows: P, pyriform; U, U-shaped; D, divergent; O, O-shaped; and S, saddle-shaped.

Though these forms are not exclusively characteristic of sex distinction, yet as may be observed in Table III, there is a slight preponderance of certain arch forms in each sex. Thus in the upper jaw the pyriform and U-shaped arch form seems to be predominant in the male, while the divergent and O-shaped form is found more frequently in the female. In the lower jaw, on the other hand, the pyriform is possessed by the male exclusively, while the divergent is in excess in the female, the U- and O-shaped being equally divided in both sexes and the saddle-shaped favored by the male.

If the dental arches as they appear in their relationship to one another be now examined, the variety of their possible combination will be found quite large. The combination most frequently observed as may be seen in Table IV is the pyriform upper with the saddle-shaped lower, appearing fifteen times. The combinations following this in frequency are the U-Shaped upper with the U-shaped lower, the pyriform upper with the U-shaped lower and the O-shaped upper appearing in equal numbers with the U-shaped and diverging lower. The remaining combinations are rather small and widely distributed.

On taking the sex factor into consideration (see Table V) the male element will be found to be more closely associated with the combinations of the pyriform

TABLE IV

SHOWING IN WHAT COMEINATION AND FREQUENCY THE ARCH FORMS APPEAR IN ONE INDIVIDUAL*

Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{P}{P}$	$\frac{P}{U}$	$\frac{P}{D}$	$\frac{P}{O}$	$\frac{P}{S}$
Frequency of each combination		3	10	3	0	15
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{U}{P}$	$\frac{U}{U}$	$\frac{U}{D}$	$\frac{U}{O}$	$\frac{U}{S}$
Frequency of each combination		0	11	4	0	5
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{D}{P}$	$\frac{D}{U}$	$\frac{D}{D}$	$\frac{D}{O}$	$\frac{D}{S}$
Frequency of each combination		0	3	2	0	4
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{O}{P}$	$\frac{O}{U}$	$\frac{O}{D}$	$\frac{O}{O}$	$\frac{O}{S}$
Frequency of each combination		1	6	6	0	2
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{S}{P}$	$\frac{S}{U}$	$\frac{S}{D}$	$\frac{S}{O}$	$\frac{S}{S}$
Frequency of each combination		0	0	0	0	1

*Letters in two upper rows indicate forms of arch. P, pyriform; U, U-shaped; D, divergent; O, O-shaped; S, saddle-shaped. Each square containing the letters represents a combination as it appears in one individual; the letter above indicating the form of the upper arch, and the letter below that of the lower arch.

TABLE V

SHOWING IN WHAT COMBINATION AND FREQUENCY THE DENTAL ARCH FORMS APPEAR IN ONE INDIVIDUAL OF EACH SEX*

Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{P}{P}$	$\frac{P}{U}$	$\frac{P}{D}$	$\frac{P}{O}$	$\frac{P}{S}$
Sex		♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
Frequency of combination		3 0	7 3	1 1	0 0	11 4
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{U}{P}$	$\frac{U}{U}$	$\frac{U}{D}$	$\frac{U}{O}$	$\frac{U}{S}$
Sex		♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
Frequency of combination		0 0	5 6	2 2	0 0	4 1
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{D}{P}$	$\frac{D}{U}$	$\frac{D}{D}$	$\frac{D}{O}$	$\frac{D}{S}$
Sex		♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
Frequency of combination		0 0	1 2	1 1	0 0	0 4
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{O}{P}$	$\frac{O}{U}$	$\frac{O}{D}$	$\frac{O}{O}$	$\frac{O}{S}$
Sex		♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
Frequency of combination		0 0	1 5	1 6	0 0	0 2
Combination of arch forms	<u>Upper</u> <u>Lower</u>	$\frac{S}{P}$	$\frac{S}{U}$	$\frac{S}{D}$	$\frac{S}{O}$	$\frac{S}{S}$
Sex		♂ ♀	♂ ♀	♂ ♀	♂ ♀	♂ ♀
Frequency of combination		0 0	0 0	0 0	0 0	1 0

*The letters in the top square indicate the forms of arch. P, pyriform; U, U-shaped; D, divergent; O, O-shaped; S, saddle-shaped. Each square containing two letters represents one combination as it appears in one individual; the letter above indicates the form of the upper arch and the letter below, that of the lower arch.

upper with the pyriform, U-shaped and saddle-shaped lower, and the U-shaped upper with the saddle-shaped lower. The female, again, gains an advantage over the male in the combinations of the O-shaped upper with the U-shaped diverging and saddle-shaped lower, the diverging upper with the saddle-shaped lower. The other combinations are more equally distributed between the sexes.

2. IS THE "DIASTEMA" IN THE ORANG DENTITION A PHENOMENON SIMILAR TO THAT FOUND IN LOWER FORMS?

"There is a 'diastema' or interval in front of the upper canine into which the point of the lower canine passes when the mouth is closed." (Tomes.)

The term "diastema," of course, is understood to convey the idea of an inter-

Fig. 6.—Front view of male orang, showing the mechanical juxtaposition of the canine teeth within the spaces or "diastemas" allotted for them.

val or interruption in the continuity of the dental series. If the dentition of the horse be considered, the diastema would be in manifestation, whether the jaws be in apposition or apart. If we, however, consider the orang masticatory apparatus as a whole, with the teeth in occlusion, as in Fig. 6, we could hardly place the diastema of the orang dentition in the same category as that of the horse; for, the space in each jaw is completely occupied by the mechanical juxtaposition of the canines when the jaws are closed. The diastema in the orang dentition may, therefore, be said to be an anatomic provision for the accommodation of the crowns of the opposing canine teeth *in toto* or in part. It is, consequently, not a space between the teeth in the sense that it occurs in the horse dentition, but rather an anatomic adaptation due to mechanical accommodation.

Moreover, the "diastema" besides presenting a break in the continuity of the crowns in the tooth series of each jaw separately, it also indicates the ex-

istence of a bony structure produced as an accompanying factor, of the interval existing between the teeth; namely, the enormously thick septum intervening between the root of the canine and that of the second incisor in the upper jaw and the roots of the first premolar and canine in the lower jaw. The range of variation in the thickness of this septum is from about 1 mm. to 13 mm. in the upper, and from 0.2 to 6 mm. in the lower. So far as was possible to determine, no correlation between this bony septum and the size of the canines, or the size and form of the dental arch was found to exist. It may, however, have some connection with the form, position, and functional activity of the opposing canine teeth. This probability will have to be verified by further studies and observation of the dentitions of this as well as the other genera in the anthropoid family.

The fact of the alveolar process being but a transient structure, coming and going with the teeth, the differences in size of this septum on the two sides

Fig. 7.

Fig. 7.—Occlusal view of upper jaw of orang (153818), showing considerable decrease in thickness of the septum anterior to the right canine sockets due to loss of lower right canine.

Fig. 8.

Fig. 8.—Occlusal view of lower jaw of same specimen as Fig. 7, showing diminution of space where the teeth were lost as compared with the normal side, also forward shifting of lower molars on injured side.

of the same dental arch where the wear of the canines is unequal, would verify the idea that this bony septum, like the rest of the osseous tissues, is subject to mechanical conditions; its bulk being increased or diminished by the mechanical influence of the opposing canines during functional activity. In proportion as this influence decreases or disappears, the thickness of the septum will diminish. An illustrative instance was observed in the specimen No. 153818 (Fig. 7). The upper left septum measures 6.3 mm., while the thickness of the right is only 3 mm. The reason for this difference was found to be due to the absence of the lower right canine, which must have been lost through some accident together with both lower premolars on that side (Fig. 8). The alveolar process of the lower jaw in that region is entirely absorbed and the distance from

the second incisor to the first molar measures 26 mm., while the homologous distance on the opposite side with the canine and premolars *in situ* measures 35 mm. It may be seen, then, that there is a decrease of 9 mm. between the second incisor and first molar of the injured side as compared with the normal one, and also that owing to the loss of these teeth, the loss of their mechanical influence upon the upper teeth brought about a decrease in the thickness of the bony septum in front of the upper right canine to the extent of 3.3 mm.

In man these conditions are variously brought to our notice by certain dis-

Fig. 9.

Fig. 10.

Fig. 9.—Occlusal view of cast of human lower dentition, showing lack of second premolars. The space for the right tooth is entirely obliterated while the left is partly visible.

Fig. 10.—Occlusal view of case of lower dentition of the same individual as Fig. 9, after the spaces for the missing teeth have been restored. The left premolar erupted and assumed its position, while the right tooth germ being absent, bone developed in the interstice to fill in the distance between the roots of the first molar and first premolar.

Fig. 11.—Side view of cast of human dentition showing lack of space between the second lower premolar and second lower molar, the first molar having been lost at an early age. The lower first molar on the right side measures 10 mm., while the space on the left side measures less than 1 mm.

turbances in development and by processes of disease. Thus, Fig. 9 represents a cast of a lower dental arch and alveolar process of an individual in which the second premolars failed to erupt. As a consequence the alveolar process destined to hold that tooth in position, failed to develop. Upon the application of mechanical stress, by means of orthodontic appliances, a space was artificially made to the extent necessary for the accommodation of the missing tooth on either side. The tooth on the left side erupted and the alveolar process developed around it. On the right side of the same jaw, although the same process for

the restoration of space was resorted to, no tooth erupted, there having been no dental germ present; but bone, nevertheless, developed to fill the gap between the roots of the separated teeth. (See Fig. 10.) The reverse phenomenon may be seen in another case (Fig. 11), where the alveolar process had developed, but owing to the loss of the first permanent molar, it disappeared again, allowing the second molar to take its position adjoining the second premolar.

If the skull of a young orang (Fig. 12) be examined before the teeth have erupted, there will be no marked differences noticed in the thickness of the septa separating the various tooth crypts. But when the deciduous dentition is fully developed, as in Fig. 13, these differences become manifest. This fact demonstrates again that the bony septa increase in thickness after the functional activity of the canines is becoming effective.

It is, therefore, quite plain that although in the orang dentition a diastema does exist, it is a manifestation of mechanical conditions brought about by the

Fig. 12.

Fig. 13.

Fig. 12.—Oclusal view of upper jaw of young orang with the teeth in their crypts but quite ready for eruption. Notice lack of marked difference in thickness of the various septa. (After Selenka.)

Fig. 13.—Oclusal view of upper jaw of young orang with deciduous dentition fully developed, showing the appearance of a small "diastema." (After Selenka.)

canines during their development and functional activity, and must be regarded in a sense different than the diastema of other forms, as those, for instance, of the ungulates.

IS LABIDONTY OR EDGE-TO-EDGE BITE A PITHECOID CHARACTERISTIC?

"Also the 'articulation' in the ape appears in a form which Welcker called labidonty." (De Terra.)

Of the fifty-one specimens with the incisors *in situ*, thirty-six showed an edge-to-edge occlusion, and fifteen had a decided overbite. The edge-to-edge occlusion is well illustrated in Fig. 14. The extent of the overbite occlusion ranged from slight lapping of the upper incisors over the lower, to a considerable projection of the upper anterior teeth, as presented in Fig. 15.

Upon the examination of more than two thousand Indian skulls, both in this

institution (The American Museum of Natural History, New York) and at the U. S. National Museum, Washington, the best Indian dentures presented an edge-to-edge relation of the anterior teeth, as in Figs. 16 and 17 (Delaware Indian). In these Indian dentitions, as well as in those of the ape showing an edge-to-edge bite, there is evidence of excessive wear of the teeth, caused evidently by vigorous use of the jaws and also probably due to the trituration of coarse food substances. The examination of two hundred Mongolian skulls, on the other hand, revealed the prevalence of an excessive overbite in the incisor

Fig. 14.—Side view of orang skull showing edge-to-edge bite of the incisor teeth.

Fig. 15.—Side view of orang skull showing overbite in incisor region.

region. (See Figs. 18 and 19, Mongolian, Urga.) As I am informed by Dr. Moore, of the U. S. National Museum, the Indian skulls exhibit a shallow broad glenoid fossa, which accommodates the oval articular process of the mandible, allowing a free movement of jaw during the act of mastication; while in the Mongolian, as I have observed, the fossa is deep and the articular process is narrow, allowing probably a more limited lateral movement of the jaw.

That these explanations are not applicable to the orang temporomandibular articulation is quite certain, for in the orang "the glenoids are 'rather universally' broad and shallow." (Hrdlicka). The wear of the incisors is, therefore, equally excessive in both the edge-to-edge and the overbite dentitions. The fact, how-

ever, remains that in the Indian dentition the percentage of the edge-to-edge relationship of the incisors is very high. If it is a pithecoïd characteristic, as suggested by various authorities, it has been inherited by man to a marked degree.

Fig. 16.

Fig. 17.

Fig. 16.—Front view of Indian skull, showing edge-to-edge occlusion of the anterior teeth.

Fig. 17.—Right side view of Indian skull of Fig. 16, showing to better advantage the edge-to-edge relationship of the front teeth.

Fig. 18.

Fig. 19.

Fig. 18.—Front view of Mongolian skull, showing excessive over-bite in the incisor region.

Fig. 19.—Left side view of Mongolian skull of Fig. 18, illustrating the same point.

So far as this investigation has been conducted, it has revealed the following facts:

1. The orang dental arch is not uniform in outline, as described by various authorities, but may be divided into five typical forms, as pointed out above.

2. Although the diastema is described as an interval occurring between the crowns of certain teeth in the dental arch, it has underlying this manifestation, a bony structure, *the root septum*, the dimensions of which are subject to the mechanical conditions brought about by developmental influences and the functional activities of the canines.

3. Though the edge-to-edge bite of the incisors is prevalent in the orang, it is not an exclusive characteristic, and may be found to exist in the Indian dentition to an equally high degree, while the overbite relationship is also of frequent occurrence in the ape.

In conclusion I wish to express my thanks and gratitude to Prof. Holmes, Dr. Hrdlicka, Dr. Miller, and Dr. Moore, of the U. S. National Museum, Washington, D. C., for their kindness and interest shown me during the course of this investigation, and to Dr. Gregory of this museum for various courtesies shown me.

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