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Variations of *Fovea anterior* in Lower Molars among Some Fossil and Recent Hominids*

By

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Introduction

In my previous description on the dentition of Amud man, it has been suggested that there are two types of *fovea anterior* in hominid lower molars and the differential occurrence of these types among various hominid groups may be a manifestation of the racial differentiation (SAKURA, 1970). One of the two is the type of "transverse furrow", which has been found in an isolated lower second molar and a lower second deciduous molar of Amud man, as well as in many of the Neanderthal specimens reported by various authors. The other is the type of "bifurcation", which has been described by WEIDENREICH (1937) in his work on Peking man (Sinanthropus), and also noticed by myself as the common type among the modern Japanese.

Distinction between the two types may be seen in the illustrations by two authors, GORJANOVIĆ-KRAMBERGER (1906) and WEIDENREICH, which are reproduced in Fig. 1. Both illustrate occlusal aspects of the lower molar, but differ from each other in style and aim. The former author makes a sketch of a real first lower molar showing mainly the enamel ridges of its crown (Fig. 1, B), while the latter author draws a schema of the enamel wrinkles of a hypothetical lower molar, showing the alignment of grooves and furrows (Fig. 1, A). Different characteristics are clearly visible, however, on these two illustrations, representing the two hominid groups, Krapina Neanderthal and Peking man. Differences are in outline of the tooth, number and relative position of the cusps, direction and shape of the ridges and grooves, and especially in the region of *fovea anterior*.

WEIDENREICH (1937), regarding the lower first and second molars of Peking man, states:

> "The area occupied by the space between the mesial edge and the inner slopes of the protoconid and metaconid shows a triangular form.... It is limited by a V-shaped furrow caused by a bifurcation of the longitudinal major furrow on its mesial end. A real "fovea anterior" does not exist unless one should choose to apply this term to the place of this bifurcation."

He further notes on the third molar that:

* This study was preliminarily presented at the 27th Joint Meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology in 1973 (SAKURA, 1974a).

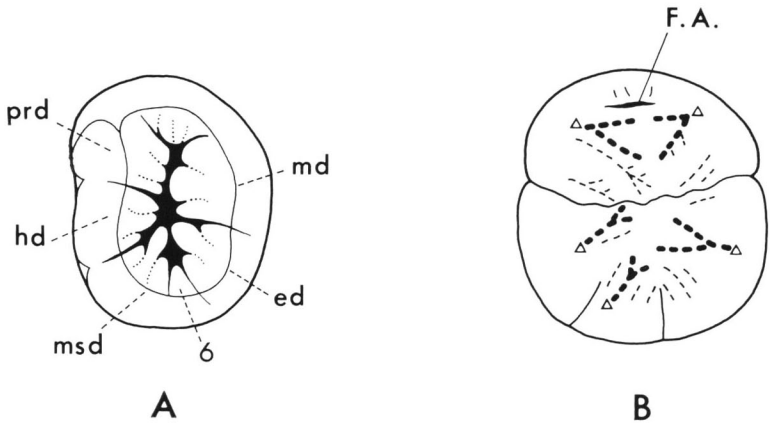

Fig. 1. Different expressions of the occlusal aspect of lower molar.
A. Schema of wrinkles of a hypothetical left M_1 of Peking Man. Redrawn after WEIDENREICH (1937: Fig. 155). prd, protoconid; md, metaconid; hd, hypoconid; ed, entoconid; msd, mesoconid (hypoconulid as usual term); 6, sixth cusp.
B. Schematic sketch of ridge arrangement of a left M_1 of Krapina Neanderthal. Redrawn after GORJANOVIĆ-KRAMBERGER (1906: Fig. 40) with modifications: small triangle, tip of cusp; interrupted line, ridge; continuous line, furrow. F.A., *fovea anterior*.

"The configuration of the region of the fovea anterior is the same as in the first and second molars described above as characteristic, that is to say, only the mesial edge is developed while a real fossa is absent."

In contrast, the investigators of Neanderthal dentition, including GORJANOVIĆ-KRAMBERGER, MCCOWN and KEITH (1939), and PATTE (1962), have repeatedly stressed the existence of well-developed *fovea anterior* in the lower molars of that hominid group.

If the *fovea anterior* is a primitive character as GORJANOVIĆ-KRAMBERGER considers, the absence of "real" ones in Peking man, who represents an earlier stage of hominid than Neanderthals, would require a proper interpretation.

In the present study, attempts will be made to examine the appearance of the types of the *fovea anterior*, rather than the presence or absence of it, in the lower molars among some early and recent hominid groups, in order to estimate the probable changes in the structure concerned through hominid evolution and diversification.

Typology of *Fovea anterior* in Lower Molars

Basic Morphology

Morphological elements of tooth crown are basically the same in the three kinds of lower permanent molars, as well as in the lower second deciduous molar. In typical lower molars with five main cusps, a longitudinal or central groove runs in mesiodistal direction between the buccal cusps (protoconid, hypoconid and hypoconulid) and the lingual ones (metaconid and entoconid). At the mesial end of the groove,

and near the mid-point between the tips of two mesial cusps (protoconid and metaconid), there usually exists a small fossa or a more or less depressed area, which is called *fovea anterior*. The same term is applied to the correspondent structures in all permanent and deciduous molars, and also in premolars, both upper and lower.

It varies in both depth and form, depending on the development and shape of its surrounding structures, i.e., the mesial marginal ridge and the ridges of the protoconid and metaconid. It may be a marked fossa, a faint depression, or absent. Its form may appear as a furrow, a triangular area, or a small pit. In such a case that the mesial accessory ridges of the two mesial cusps are well-developed and tend to form an anterior transverse crest, it may exist as a separated fossa having no contact with the central groove.

Typology

In this study, the variations of *fovea anterior* are classified into the following types according to the pattern of furrows in the region, regardless of the degree of development of the *fovea* (Fig. 2).

Type T (*Transverse furrow*)

A relatively straight furrow runs in bucco-lingual direction, and forms a T-shaped pattern together with the mesial part of the central groove, though the transverse and longitudinal portions are occasionally separated from each other. In some cases, accessory furrows diverge from the main transverse furrow. Only this type of *fovea* has been considered to be the real one by some authors.

Type Y (*Bifurcated furrow*)

The central groove is bifurcated at its mesial end into a V-shaped furrow, forming as a whole a Y-shaped pattern. Two arms of the V-shaped furrow, making a marked angle between them, run obliquely and may extend close to the mesial margin of the crown. A more or less depressed triangular area is frequently seen around the point of bifurcation, although WEIDENREICH does not regard this type as a real *fovea*. Some accessory furrows may exist between the two arms of the main V-shaped furrow. In some cases, one of the two arms of the furrow may be separated from the central groove, or may be lacking. Even in the latter case, however, the remaining arm is oblique, not transverse, in direction.

For precise discrimination of this type Y from the type T, a criterion is made in the present study that the angle between the two arms of furrow is less than 120°. The angle is measured at the principal part of the furrow near the point of bifurcation, but a very minute part of it, within a range of 0.5 mm from the point of bifurcation, is ignored.

Type I (*Longitudinal furrow*)

The central groove may end mesially with or without a small pit. In some cases, a longitudinal furrow as a continuation of the central groove exists and may extend close to the mesial margin of the crown. In any case the groove or furrow forms a

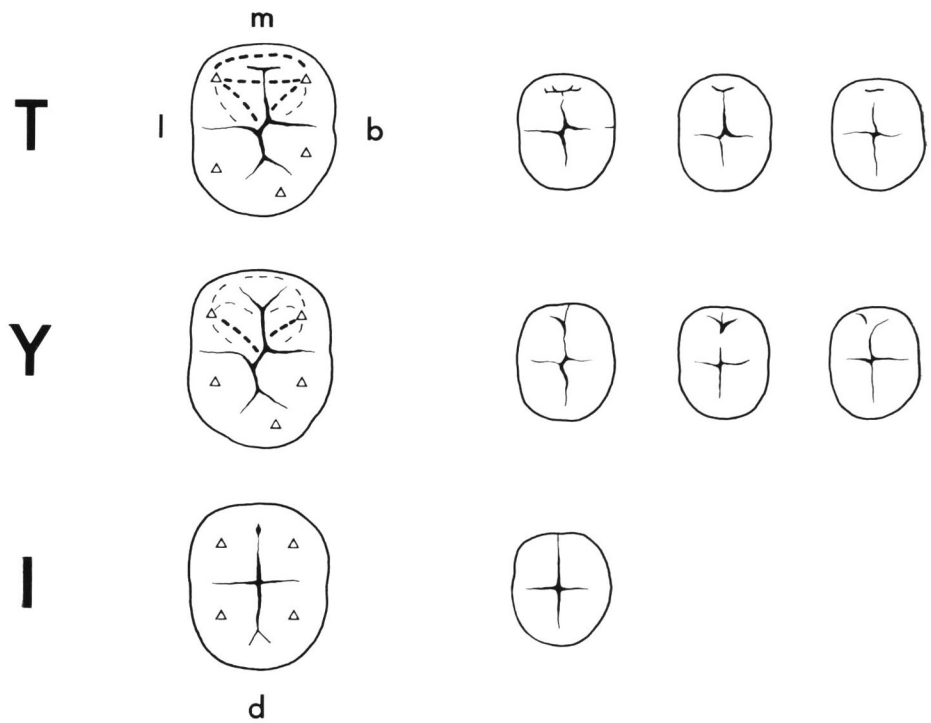

Fig. 2. Diagram of the main types of *fovea anterior* in lower molar. (Occlusal views of right teeth: m, mesial; d, distal; b, buccal; l, lingual sides)
T, type of transverse furrow; Y, type of bifurcated furrow; I, type of longitudinal furrow. In two of the three larger figures (left), showing typical forms, thick and thin interrupted lines indicate relatively marked and less marked ridges respectively. The smaller figures (right) show some of the variations in each type.

simple longitudinal I-shaped pattern in the region of *fovea anterior*, and no other oblique or transverse furrows are present. This type is most frequently seen in the teeth with markedly reduced enamel structures.

Besides the three types defined above, there may be cases of the following categories.

Undefinable

The mesial part of the tooth is amorphous and does not show regular arrangement of morphological elements. So the region of the *fovea* can not be classified into any of the three defined types mentioned above.

Not Observable

The region of the *fovea* can not be observed because of the loss of enamel substance. This condition is caused most frequently by the tooth wear.

Materials and Results

Fossil Hominid Groups

Materials used for the examination of fossil hominid teeth are all reproductions of original specimens, except for the tooth of Amud man. They principally consist of sketches and photographs which have been presented in publications by various authors. Those of teeth in the category "not observable" or those without enough details are omitted. Available casts have also been examined to complement the observation, but most of them found less useful than sketches or photographs for the purpose of observing such minute structures of tooth as *fovea anterior*.

Authors of the source publications used, and their symbols that will appear in the tables, are as follows:

GORJANOVIĆ-KRAMBERGER, 1906 (G)
WEIDENREICH, 1937 (W)
MCCOWN and KEITH, 1939 (M)
ROBINSON, 1956 (R)
DAY, 1965 (D)
TOBIAS, 1967 (T)

As for the fossil materials the specimens of three hominid groups, *Australopithecus*, Peking man and Neanderthals, were examined. A few additional specimens found in the sites closely related to those of the three groups were also examined. The results obtained of the fossil specimens are shown in Tables 1–3, and summarized below.

Australopithecus (Table 1)

In the teeth of *Australopithecus*, structure of the enamel surface is in general rich in relief. The cusps and ridges are mostly well-developed and the grooves or furrows are relatively deep and distinct. The *fovea anterior* is, therefore, in most cases clearly observed, and no case of the category "undefinable" or type I is found. Among the 24 molars examined, type T and type Y equally occur in both the species, *Australopithecus africanus* and *A. robustus*, when the three kinds of molar are combined together. Even if the small sample size is taken into account, apparently it can be said that both the two types of *fovea anterior* have considerable frequencies in *Anstralopithecus* without a great difference between them.

Table 1 includes six teeth of two individuals who are probably attributable to *Homo erectus*, from Swartkrans (SK 15) and Olduvai (OH 13). The taxonomic evaluation of the latter individual, together with the other specimens of so-called "Homo habilis", has been presented elsewhere (SAKURA, 1974b). Types T and Y are observed in these teeth, and it is noticeable that the second molars of both sides of SK 15 bear *fovea anterior* of the type I.

Peking Man (Table 2)

The teeth of Peking man mostly have well-developed and distinct cusps. But some of the ridges, especially the accessory ridges of the cusps and the marginal ridges,

Table 1. Occurrence of the types of *fovea anterior* in lower molars of *Australopithecus* and its relatives from South and East Africa.

Type	Species	Occurrence		
		M1	M2	M3
T	*A. africanus*	1 Sts 37, l (R)	3 Sts 52b, r (R) MLD 2, l (R) OH 7, l (D)	2 T.M. 1518, r (R) Sts 52b, r (R)
	A. robustus	3 SK 6, l (R) SK 23, l (R) SK 843, l (R)	3 SK 6, l (R) SK 25, r (R) SK 843, l (R)	
	Total	4	6	2
	Homo erectus (?)	1 OH 13, r (D)	1 OH 13, r (D)	
Y	*A. africanus*	5 Taung, rl (RD) Sts 9, r (R) Sts 24, r (R) MLD 2, r (RD)		1 OH 4, l (cast) (M2 ?)
	A. robustus	1 SK 25, r (R)	1 SK 1, l (R)	4 SK 6, r (R) SK 22, r (R) SK 23, l (R) SK 841, l (R)
	Total	6	1	5
	Homo erectus (?)			3 SK 15, rl (D) OH 13, r (D)
I	*Homo erectus* (?)		2 SK 15, rl (D)	

Sts: Sterkfontein (also T.M. 1518).
MLD: Makapansgat.
SK: Swartkrans (SK 15: "Telanthropus I").
OH: Olduvai. The specimens of so-called "Homo habilis" are placed in appropriate positions separately. The specific status of OH 4 is uncertain at present.

tend to be not so developed, relatively to the grooves or furrows. Of all the 18 specimens examined, 16 specimens show the type Y of *fovea anterior*. Only one case of the type T and one undefinable case occur in the remaining specimens. The type I is not observed in this group. It seems most probable that the type Y of *fovea anterior* is markedly dominant in the lower molars of Peking man.

In addition, it is observed that the two right lower second molars from Upper Cave of Choukoutien, that are regarded to be of Upper Palaeolithic age, have *fovea anterior* of the type Y.

Table 2. Occurrence of the types of *fovea anterior* in lower molars of Peking Man (Sinanthropus) and Upper Cave Man (in parenthesis) from Choukoutien, China.

Type	Occurrence		
	M1	M2	M3
T	1 Sin 137′, l (W)	0	0
Y	4 Sin 36, l (W) Sin 46, l (W) Sin 98, r (W) Sin 99, r (W)	5 Sin 43, r (W) Sin 44, l (W) Sin 45, r (W) Sin 107, r (W) Sin 108, r (W) (U.C., rr (W))	7 Sin 46, l (W) Sin 50, l (W) Sin 52, l (W) Sin 114, r (W) Sin 115, r (W) Sin 116, l (W) Sin 131′, r (W)
I	0	0	0
Undefinable	1 Sin 34, l (W)	0	0

Sin: Sinanthropus (*Homo erectus*).
U.C.: Upper Cave Man, Palaeolithic.

Neanderthals (Table 3)

Of the Neanderthal material, 37 specimens were observed. Most of them are derived from Europe, some from West Asia, and a few from North Africa. They all belong to the Neanderthal or Neanderthaloid group in ordinary sense, with one exception of Heidelberg specimens. Although the affinity of the Heidelberg jaw from Mauer is still controversial, I prefer to regard it as a Neanderthal-like fossil, in agreement with the opinion of WEIDENREICH.

The lower molars of this group have in general well-developed marginal and accessory ridges, relatively to the central groove. The *fovea anterior* is frequently separated from the central groove by an anterior transverse crest, which is formed by continuation of the mesial accessory ridges of the two mesial cusps. As the crest and the mesial marginal ridge are both developed and transversely directed, the *fovea* between them naturally appears as a transverse furrow.

The result obtained apparently indicates that the type T of *fovea anterior* is overwhelmingly dominant in this group, especially for the first and second molars. The type Y occurs only in the three specimens of third molar, which reveal some tendency to reduced or amorphous enamel structures as in the cases of type I and "undefinable".

Recent Hominid Groups

Materials

The recent hominid materials are composed of two racial groups, namely European White and Japanese. The European sample is the teeth of European crania series at the Department of Medicine, the University Museum, the University of Tokyo. The

Table 3. Occurrence of the types of *fovea anterior* in lower molars of Neanderthals from Europe, West Asia and North Africa.

Type	Occurrence		
	M1	M2	M3
T	14 Gibraltal, r (W) Moustier, r (W) Krapina C, r (G) Krapina D, l (G) Krapina E, l (G) Krapina G, r (G) Krapina H, rl (G) Krapina I, r (G) Krapina, l (G) Tabun S. III, l (M) Shukubah, r (M) Skhul I, r (M) Skhul X, l (M)	11 Gibraltal, r (W) Moustier, r (W) Ehringsdorf, l (W) Krapina C, r (G) Krapina E, l (G) Krapina G, r (G) Krapina H, rl (G) Krapina I, r (G) Krapina, l (G) Amud I.M., r	5 Moustier, r (W) Krapina G, r (G) Krapine H, rl (G) Krapina, r (GW)
Y	0	0	3 Heidelberg, r (W) Haua Futeah I, l (T) Haua Futeah II, l (T)
I	1 Ehringsdorf, l (W)	1 Heidelberg, r (W)	0
Undefinable	0	0	2 Krapina, l (G) Krapina, r (G)

Amud I.M., Amud Isolated Molar (SAKURA, 1970).
For symbols of sourecs (in brackets), see in the text.

number of the lower molars examined is 94, implanted in 27 jaws. Of them, 16 have their origins in Germany, 4 in Russia, 3 in France, 3 in Czechoslovakia, and 1 in the Netherlands. Teeth of both sexes and both sides were combined in view of the small sample size.

The Japanese sample is the teeth derived from a cemetery in Tokyo and deposited in my laboratory. They all belong to male individuals. The lower molars of both sides, 105 in number, were examined.

Results (Table 4)

The European teeth in general have a marked tendency to reduction in morphological elements of the crown. The cusps tend to be simplified in form with not well-differentiated ridges. In spite of it, swelling of the ridges, including the mesial marginal ridge, tends to remain. The main groove system frequently shows a simple "plus" pattern. In many instances, the region of *fovea anterior* presents poor relief. In such teeth, the type of the region may easily become "not observable" with ad-

Table 4. Occurrence of the types of *fovea anterior* in recent European White and Japanese,

Type	European			Japanese		
	M1	M2	M3	M1	M2	M3
T	7	7	5	0	5	2
Y	1	3	2	20	21	16
I	10	16	9	5	14	12
Undefinable	1	3	2	1	0	6
Not Observable	19	8	1	3	0	0
Total	38	37	19	29	40	36

vanced wear. Of the three defined types, the type I occurs most frequently in every kind of lower molars. Of the remaining two types, the type T seems to be more frequent than the type Y, though both the occurrences are absolutely low in this group.

The Japanese teeth also show some features of reduction, but to a less extent than European teeth on the average. The mesial accessory ridges of the two mesial cusps are frequently fused with the main ridges, and tend to be directed obliquely distalwards as in the teeth of Peking man. The mesial marginal ridge is often very faint and easily broken down by continuation of furrows. The occurrence of the type I is not so high as in the European group, especially for the first molars. The type Y of *fovea anterior* is clearly dominant in occurrence against the type T. This condition of the Japanese is nearly comparable with that of Peking man, but quite different from that of Neanderthals.

So far as only the two types are taken into account, the difference in occurrence of these types between European and Japanese is statistically significant for every kind of lower molars, although a supposition of random sampling is somewhat incorrect in strict sense because of the possible inter-side correlations. Here it can be merely suggested that the European group has a closer affinity to Neanderthals than to Peking man and Japanese in this respect.

Discussion and Conclusion

According to KORENHOF (1960), the *fovea anterior* has been noticed by SELENKA in the molars of *Pongo* as early as 1898. Since then, the structure in pongid as well as in hominid dentition has been described and discussed by various authors, mainly in regard to its phylogenetical significance. For example, GREGORY and HELLMAN (1926) have considered it to be the remnant of the bottom of the valley of the primitive trigonid of Eocene mammals. As the structure commonly appears in pongids as a distinct transverse furrow, while in recent hominid it rarely appears distinct, it has been recognized as a pithecoid or primitive character. But the variation of its form through hominid evolution has scarcely been investigated so far in detail.

KORENHOF (1960) made a very detailed description of the *fovea*, with the aid of an appropriate typology based on the evolutionary changes in the structure. But his study was concerned only with the upper molars, which I have to deal with elsewhere.

The results of the present study show that the two principal types of *fovea anterior*, i.e. type T and type Y, exist even in early hominid, and that differential occurrence of the two types appears in later hominid groups. Dominance of the type T is seen in Neanderthals and European, while dominance of the type Y is seen in Peking man and Japanese.

Since each combination of groups consists of those derived from close geographical areas, it is naturally conceived that the common character in each is hereditary one within the same hominid lineage, the lineage which may be called race in broader sense. In other words, dominance of the type T seems to be a Caucasoid character, or more strictly, a character of the ancestors of recent Caucasoid, such as the Neanderthals considered here. On the other hand, dominance of the type Y is possibly a Mongoloid character, which has been inherited from a certain racial group of *Homo erectus* like Peking man.

The status of Peking man as an ancestor of Mongoloid races has already been pointed out by WEIDENREICH (1937), based on the high intensity of shovelling in the upper incisors of this hominid. The possibility that dominance of the type Y is another Mongoloid character seems to be supported by my preliminary examination of a few dentitions of other Mongoloid races scuh as Chinese, Korean, Javanese and American Indian, the data of which are not presented here. On the other hand, a few examples of Negro dentition give me a hint that the Negroid race may have an affinity in this respect to the Neanderthals and Caucasoid.

As repeatedly mentioned above, the difference in appearance or types of *fovea anterior* is mainly due to differences in its surrounding morphological elements, particularly in the mesial marginal ridge and the mesial accessory ridges of two mesial cusps, and the formation of the mesial portion of the central groove. All these elements may have been subjected to reduction through hominid evolution. But reduction seems to have occurred not simultaneously in every structure within a tooth and in every hominid lineage after racial differentiation. Hence, changes in the relationship between elements could have taken place differently in the course of evolution, resulting in diversification of dominance of the two types of *fovea anterior* in different lineages, such as Caucasoid and Mongoloid races.

The present study also suggests that the diversification concerned occurred early in the time of *Homo erectus*, and the different features between lineages have been retained to some extent until the present time, though they will inevitably tend to converge to the more reduced type I of *fovea anterior*.

The suppositions presented here, of course, need to be confirmed by an extensive study on much more materials of both fossil and recent hominid dentitions in the future.

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References

DAY, M., 1965. *Guide to Fossil Man.* xvi+289 pp. Cleveland & New York, The World Publishing Co.

GORJANOVIĆ-KRAMBERGER, K., 1906. *Der diluviale Mensch von Krapina in Kroatien. Ein Beitrag zur Paläoanthropologie.* 59–278 S., Taf. 1–14. Wiesbaden, C. W. Kreidel's Verlag.

GREGORY, W. K. and M. HELLMAN, 1926. The dentition of *Dryopithecus* and the origin of man. *Anthrop. Papers Am. Mus. Nat. Hist.*, **28**, Pt. 1: 1–123, 25 pls.

KORENHOF, C. A. W., 1960. *Morphogenetical Aspects of the Human Upper Molar.* 368 pp., 15 pls. Utrecht, Uitgeversmaatschappij Neerlandia.

MCCOWN, T. D. and A. KEITH, 1939. *The Stone Age of Mount Carmel: The Fossil Human Remains from the Levalloiso-Mousterian*, Vol. **2**. xvii+390 pp., 27 pls. Oxford, Clarendon Press.

PATTE, E., 1962. *La Dentition des Néanderthaliens.* 307 pp. Paris, Masson et Cie.

ROBINSON, J. T., 1956. *The Dentition of the Australopithecinae.* vii+179 pp. Pretoria, Transvaal Museum.

SAKURA, H., 1970. Dentition of the Amud Man. *In*: (H. SUZUKI and F. TAKAI, eds.) *The Amud Man and His Cave Site*, IX: 207–229, pls. 33–38. Tokyo, Univ. of Tokyo.

SAKURA, H., 1974a. Variation of *fovea anterior* in mandibular molars. *J. Anthrop. Soc. Nippon*, **82**: 88–89. (in Japanese)

SAKURA, H., 1974b. Evolutionary problems of *Australopithecus*: The dental aspect. *Biological Science (Tokyo)*, **26**(4): 194–199. (in Japanese)

TOBIAS, P. V., 1967. The hominid skeletal remains of Haua Futeah. *In*: C. B. M. MCBURNEY: *The Haua Fteah (Cyrenaica) and the Stone Age of the South-East Mediterranean*: 338–352, pls. A1–4. Cambridge Univ. Press.

WEIDENREICH, F., 1937. The dentition of *Sinanthropus pekinensis.* A comparative odontography of the hominids. *Palaeontologia Sinica*, no. 101 (N.S.D. no. 1): i–v, 1–180, pls. 1–36, diagrams 1–49.