Morphological Investigation of Innominate Bones from Pleistocene in Japan with Special Reference to the Akashi Man

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Abstract All the human male innominate bones seemingly from the Pleistocene age were morphologically investigated based on the recent advances in knowledge. New measurement methods were applied to these innominates as well as the available fossil innominate casts and Recent Japanese innominates for comparison. For this measurement and observation new casts were made from all the fossils and restored so as to presume the whole form of the ilium. Some of the multivariate analyses were used for the objective comparison. The results indicate that the Akashi man is comparable neither to Erectus nor to Neanderthal nor to Pleistocene Sapiens but to modern Sapiens, whereas the Minatogawa man and the Mikkabi man are in many respects archaic and seem certain to be the Pleistocene Sapiens.

INTRODUCTION

Human skeletal remains from the Pleistocene age are rather poor in Japan. They are mostly fragments of various bones except in the case of the Minatogawa man. However, there are several innominate bones among them. Some of these bones are available for morphological study. They have actually been studied, but these studies carried out some decades ago, do not seem to be appropriate from the viewpoint of recent knowledge. Furthermore, the oldest finding, named Akashi, is the most famous, but it was collected in a clod dropped from the wall of a cliff which consisted of outcrops of

Pleistocene and Holocene deposits. Thus it left a stratigraphical doubt and, later on, a morphological one as well.

The innominate bone among the postcranial bones shows the most remarkable change during human evolution. Therefore, it is important to investigate thoroughly the Japanese Pleistocene innominates based on recent advances in knowledge.

The present paper aims in this respect to examine these innominate bones comparing them with those of recent and prehistoric Japanese as well as with those from the Pleistocene age around the world in each stage of human evolution.

MATERIALS

Preparation of Fossil Specimen

In order to study the form of the in-

This paper is dedicated to Emeritus Professor Hisashi SUZUKI of the University of Tokyo in commemoration of his seventieth birthday.

nominate bone in detail, it is desirable to use intact bones or their casts, and it is desirable that they are complete in form. However, it is impossible to obtain complete fossil innominates from Pleistocene. Therefore the fossil innominates were carefully restored where possible to presume the whole form of the ilium and the ischial body.

For this purpose new casts were taken from the fossil innominates or their casts. The restoration was carried out on these new casts. These casts were made of yellow gypsum and white gypsum was used for the restoration.

It is important for the comparative study of the fossils to observe various fossil casts of the same color. Otherwise, the proper color of fossil or cast often misleads the morphological observation.

Selection of Specimen

Only male innominates were used in the case of Japanese specimen, because, as is often described, the male bone shows more marked stage-specific characters than the female.

The available Japanese specimens and casts of the fossil hominid were mainly left. Therefore, the comparison was done in left innominates.

Innominates from Pleistocene in Japan

Innominate bones found in Japan apparently from the Pleistocene deposits are as follows:

Akashi

A male left innominate without the pubis (Plate 4). A part of the ilium is

broken off. It was discovered by NAORA, a geologist, at Akashi, Western Japan. He found it in a clod dropped onto a terrace near the seashore from the wall of a cliff which consisted of outcrops of a series of Pleistocene and Holocene deposits. Considering from the nature of the clod, he maintained that the bone had been in a Pleistocene deposit (NAORA, 1936). The morphological features of this bone were reported by HASEBE (1948). He concluded that this bone was different from that of *Homo sapiens*. This bone was destroyed during the Second World War. Only a few casts remain. Afterwards, the wall was excavated but there were no findings at all. Examinations of the deposits and of the artifact-like stones were carried out. Many doubts arose from these examinations (reviewed by WATANABE, 1970).

Mikkabi

An anterior part of a male right ilium with upper part of the acetabulum (Plate 5). It was found in 1959 in a fissure deposit from the Pleistocene age in a limestone quarry at Mikkabi, Central Japan. This bone was discovered by a worker of the quarry, who had been asked by SUZUKI and TAKAI, anthropologist and paleontologist respectively, to find fossil bones and to observe the deposits which yielded these bones. Excavation and geological investigation organized by them were carried out in a month after this discovery. Several human bones were uncovered together with many mammalian fossils during this excavation. The results of this field work and related laboratory studies were reported by SUZUKI

Plate 1. Restored casts of right innominate of Sts-14 and left innominate of OH-28.

Plate 2. Restored casts of left innominates of Arago and Düsseldorf.

Plate 3. Restored cast of left innominate of Minatogawa I.

Plate 4. Restored cast of left innominate of Akashi and cast of right innominate fragment of Hamakita.

Plate 5. Cast of right innominate fragment of Mikkabi and left innominate of a Recent Japanese,

Plate 6. Parallel light moiré contourgrams of ilia used in the present study. Left, from top to bottom, *Australopithecus*, *Erectus* and *Neanderthal*; right, upper two are from Pleistocene in Japan and bottom, Recent Japanese. The ilium is so held that the line between anterior inferior spine and posterior inferior spine and the line between the top of the tubercle of iliac crest and the top of the acetabular brim are approximately orthogonal to the direction of the lens of camera. Height interval of fringe is 2mm.

et al (1962).

Hamakita

A fragment of a female right ilium around the greater sciatic notch (Plate 4). It was found in 1960 in a cave deposit of a limestone quarry at Hamakita, Central Japan. It was uncovered by workers of the quarry who were also asked by SUZUKI and TAKAI to do the same as in the case of Mikkabi. In 1962 and 1963, excavations and geological surveys organized by them were carried out. Studies on this site and on discoveries were reported by SUZUKI *et al* (1966).

Minatogawa I, II, III, IV

Four individual skeletons remain together with a number of bones from unknown individuals. They have more or less broken innominates of both sides. I is male and others are female. These fossils were collected in a limestone quarry at Minatogawa, island of Okinawa, by OYAMA, a so-called amateur paleontologist living in Okinawa, from 1968 to 1974. Excavations and geological surveys were organized by SUZUKI and carried out in 1968 and 1969. Studies of human fossils and of geology were published by SUZUKI *et al* (1982). The left innominate of Minatogawa I is shown in Plate 3.

Innomimates of Recent and Prehistoric Japanese

The standardized metrical characters of Japanese for comparison were obtained from the published data on recent male Japanese in the Kinai region where is near the locality of Akashi (MIYAMOTO, 1927), and the data of the male skeleton

excavated at the Tsukumo site from the prehistoric Jomon age where is also near the locality of Akashi (TABATA, 1928).

For further comparison of detailed characters it is necessary to use intact bones. In this respect twelve left innominates of recent Japanese males were selected at random from the skeletal collections stored in the Department of Medicine of the University Museum, The University of Tokyo and in the Department of Anatomy of the Dokkyo University School of Medicine. They consisted of No. 2138, No. 2156, No. 2159, No. 2177, No. 2178, No. 2390, No. 2394, No. 2547 and No. 2593 from the former and No. 54, No. 129 and No. 143 from the latter.

Cast of Innominate of Fossil Hominid

In order to compare many detailed characters with fossil hominid innominates it is necessary to use their casts, though their number becomes limited. The cast of fossil hominids used in the present study were as follows:

Australopithecus stage

[Sts-14] Right innominate, discovered at Sterkfontain in South Africa during 1936-1949. It has been described by many authors. The cast was obtained from the Wenner-Gren Foundation (Plate 1).

Erectus stage

[OH-28] Left innominate, discovered at Olduvai Gorge in Tanzania in 1970 and reported by LEAKEY (1971) and DAY (1971). The cast was obtained from the National Museums of Kenya (Plate 1).

[Arago]* Left innominate, discovered at

Arago, Tautaval in France in 1978 and reported by de LUMLEY (1979). The cast was given by Professor de LUMLEY to the University Museum of The University of Tokyo (Plate 2).

Neanderthal Stage

[Düsseldorf] Left innominate, originally named "Neandertal" but called Düsseldorf in the present paper in order to distinguish it from the name of stage. It was discovered at Neandertal in Germany in 1856 and reported by FUHLROTT and SCHAAFFHAUSEN (1857). The cast used in the present study was stored in the Medical Museum of The University of Tokyo (Plate 2).

GENERAL VIEW

Form in general

As seen in Plates 4 and 5, Hamakita

Innominate is such a small fragment that morphological observation is impossible, while the bone of Mikkabi is fragmental but observation is possible as to the anterior part of the ilium. The innominates of Akashi and Minatogawa I are sufficient for the purpose of observation of the ilium and the ischial body, as seen in Plates 3 and 4.

It seems at a glance that Akashi innominate is similar neither to Neanderthal nor to Erectus nor to Australopithecus but to the Recent Japanese. This bone seems also different from the innominate of Minatogawa I. The bone of Minatogawa I seems relatively similar to the Recent Japanese but also somewhat similar to Düsseldorf.

The innominate of Akashi seems generally smaller than the usual recent or

Table 1. Standardized metrical characters of innominate bones used in the present study.

Item with MARTIN's Number	(1) Height of Pelvis	(9) Height of Ilium	(12) Width of Ilium	(9:12) Height- Width Index of Ilium	(13) Width of Iliac Blade	(15) Height of Ischium	(22) Maximum Diameter of Aceta- bulum	(32:31) Sciatic Notch Index
Specimens								
<i>Australopithecus</i>								
Sts-14	—	99	(107)	(93)	(79)	(59)	(38)	48
<i>Erectus</i>								
OH-28	—	((139))	((175))	((79))	(115)	—	56	69
Arago	—	144	(186)	(77)	(114)	—	59	96
<i>Neanderthal</i>								
Düsseldorf	(230)	(148)	(173)	(86)	(115)	(92)	60	87
<i>Pleistocene Japanese</i>								
Minatogawa I	(195)	126	(156)	(81)	102	(71)	48	(68)
Akashi	(182)	117	(126)	(93)	72	(74)	48	67
<i>Jomon Age Japanese</i>								
Tsukumo (n s)	11 7.5209	11 5.4921	9 6.2805	9 2.9351	13 8.3451	14 4.3959	14 2.7012	3 7.8886
(M)	190.8	130.8	150.2	87.4	90.2	84.6	54.3	61.0
<i>Recent Japanese</i>								
Kinai (n s)	30 9.6773	30 6.3608	30 6.3428	30 2.5746	30 4.5674	30 4.5708	30 2.2581	30 9.0740
(M)	191.1	127.4	147.9	84.5	88.6	82.7	53.7	68.0

prehistoric Jomon Japanese innominates and its ilium seems relatively higher and narrower than the latter. The standardized metrical characters show these tendencies as seen in Table 1. However, objective conclusion must be obtained from statistical analysis.

Statistical analysis

Usually it is desirable for the numerical analysis of bone morphology to use the

standardized metrical characters described in MARTIN's textbook. However, those metrical characters available for the fossil specimens concerned are rather limited, representing only simple heights or widths. A principal component analysis carried out of those characters excluding indices seen in Table 1 indicates strong influence of size factor over all characters, though some other minor factors can be

Table 2. Component loadings obtained from the principal component analysis of the thirty Recent Kinai Japanese males.

Principal Component	I	II	III
Eigenvalue	4.598	0.519	0.371
Cumulative Proportion	0.766	0.853	0.915
(Component Loading)			
1. Height of pelvis	0.915	-0.216	-0.258
9. Heights of ilium	0.933	0.062	-0.160
12. Width of ilium	0.863	0.154	0.403
13. Width of iliac blade	0.793	0.515	-0.213
15. Height of ischium	0.842	-0.420	-0.039
22. Max. diameter of acetabulum	0.898	-0.053	0.267

Table 3. Results of the test for rejection of observed vectors applied to the innominate bones from Japan used in the present study.

Population(S) Characters	Recent Kinai Japanese($n=30$)	
	9. Height of ilium	
	12. Width of ilium	
	13. Width of iliac blade	
	15. Height of ischium	
	22. Max. diameter of acetabulum	
Specimen(x)	Observed F	Probability($x \in S$)
Tsukumo 2	0.766	0.583
Tsukumo 27	1.698	0.172
Tsukumo 30	2.114	0.097
Tsukumo 32	1.194	0.341
Tsukumo 33	0.629	0.679
Akashi	3.855	0.0125
Minatogawa I	9.432	0.000378

observed, as shown in Table 2. Therefore the statistical analysis of those characters may be favorable for use within a relatively homogeneous population.

Hence, the statistical analysis of those characters is limited to the specimens in Japan. The test for rejection of vectors from a certain vector population (a kind of multivariate analysis) formulated by MASUYAMA (1943, Note 1) is applied. The objects are Akashi and Minatogawa I as well as five available Tsukumo specimens from the prehistoric Jomon age, while the population is Recent Kinai Japanese innominates. As shown in Table 3, the results reveal that the Akashi specimen, though it is small, is included to the Recent Kinai Japanese together with Tsukumo specimens at a probability of 0.01, while Minatogawa I is completely rejected. It can be concluded from these facts that the Akashi specimen can be an in-

nominate of a very small Recent Japanese or at least of a small individual belonging to any Japanese population from the Holocene prehistoric to the recent age.

A multidimensional scaling, using the shape distance matrix based on the same characters and applied to the same specimens, and 99% tolerance ellipse of Recent Kinai Japanese computed from this results indicate not only the same conclusion but also the fact that Akashi is far from Minatogawa I and considerably distant from Tsukumo men from the prehistoric Jomon age (Fig. 1). When seen from the location of the mean of thirty Recent Kinai men, Akashi is shifted to the direction inverse to Tsukumo and Minatogawa. It is possible to conclude from the results of these analyses that the Akashi innominate is a rather modern one while Minatogawa I specimen is completely different from the Holocene Japanese.

CONTRIBUTION 67.5 %

Fig. 1. Two-dimensional demonstration of the results obtained from the multidimensional scaling of various innominates from Japan, based on the shape distances using the standard deviations of Recent Kinai Japanese. The normality of the two variables shown of the Recent Kinai Japanese is verified by the k -statistics test according to FISCHER (1953) or KISHINE (1977) see Note 2. The tolerance ellipse is made based on this result.

SURFACE STRUCTURES

General remarks

Generally, various structures of the surface can be seen in the case of the innominate bone. They are important in studying the fossil innominate. Because the specimens in the present study are more or less broken, the observable structures are limited. Nevertheless, several structures can be examined on the Japanese fossil specimens in order to compare with fossil hominids from different stages. These structures are generally three-dimensional and hardly quantified. Therefore, their characters are represented by

grades as seen in Table 4. Some of these structures are explained as below.

Sigmoid curvature of iliac crest

The iliac crest seen from above generally shows a sigmoid curvature. McCOWN and KEITH (1939) pointed out that this curvature is rather weak in Neanderthals and strong in Sapiens. The presumed curvature of the specimens used in the present study are shown in Fig. 2. It is observable that this curvature becomes more pronounced from the Australopithecus stage to the Sapiens stage. In this respect Akashi is a modern Sapiens type. Minatogawa I is also a Sapiens type but somewhat archaic.

Table 4. Observable surface structures.

Item	Australo-pithecus		Erectus		Neanderthal	Pleistocene Japanese		
	+++ : pronounced ++ : moderate + : slight - : absent	Sts-14	OH-28	Arago	Düsseldorf	Minatogawa I	Mikkabi	Akashi
Sigmoid Curvature of Iliac Crest seen from above		+		+	++	++		+++
Concavity of Anterior Interspinous Border		+++	+++	+++	+++	++	++	+
Position of Root of Vertical Iliac Buttress Seen from Acetabulum*		--	-	-	±	±	±	+
Elevation of Surface Ridge of Vertical Iliac Buttress		#	+++	+++	++	++	+	+
Development of Supraacetabular Fossa		++	+++	+++	++	+	+	-
Development of Iliac Sulcus for Iliopsoas Muscle		+	++	+++	+++	++	+++	+
Angulation between Inner Surfaces of Ilium and Ischium		+++	++	+++	+++	++	++	+

*: +=anterior, ±=middle, -=posterior, --=far posterior

#: not identically comparable

Anterior superior iliac spine and inter-spinous notch

As shown in Fig. 3, there are two parallel tendencies, in that the roundness of the anterior superior spine and the depth of

this notch gradually seem to decrease from the *Australopithecus* stage to the *Sapiens* stage. All the Japanese innominates from Pleistocene are *Sapiens* type in this respect.

Fig. 2. Presumed sigmoid curvatures of the iliac crest of the left innominate, when seen from above along the iliac crest. The right innominate of Sts-14 is inverted for comparison. TC, tubercle of crest; AS, anterior superior spine; PS, posterior superior spine.

Fig 3. Shape of the anterior border of the ilium. The contour was drawn from the tubercle of crest (TC) via anterior superior spine (AS) to anterior inferior spine. Note the S shape in *Australopithecus* and *Erectus* (Sts-14, OH-28, Arago) showing marked contrast to the dog-leg shape in *Sapiens* (Minatogawa, Mikkabi, Akashi Recent Japanese).

Tubercle of iliac crest

When the ilium is observed from above, a tubercle can be seen at the anterior turning point of the sigmoid curvature. This tubercle is anteriorly located in *Australopithecus* and relatively posteriorly in *Sapiens* according to ROBINSON (1972). The backward shift of this tubercle is obvious from the *Australopithecus* stage to the *Sapiens* stage, as seen in

Plate 6 and Fig. 2. This fact indicates that Akashi and Minatogawa I are both *Sapiens*.

Vertical iliac buttress

Generally a bony elevation can be seen on the lateral surface of the ilium from the tubercle of the iliac crest to the region of the acetabulum. This long elevation was called the "vertical iliac bar" by McCOWN and KEITH (1939) and

Fig.4. Scheme of the position and inclination of the vertical iliac buttress and the horizontal iliac bar in *Erectus* and *Recent Sapiens*. Left, frontal section; right, lateral iliac view. Note the differences in the intersecting point of the vertical iliac buttress and the horizontal iliac bar and in the lateral cant of the iliac blade.

the "vertical iliac buttress" by ENDO and KIMURA (1970). This is equivalent to the "acetabulo-cristal buttress" named by ROBINSON (1972). Its upper end is always identical to the tubercle, but the lower end is different according to the evolutionary stage. A comparison of this buttress between Erectus and Sapiens is schematically shown in Fig.4. As seen in Table 4, Akashi is modern while Minatogawa I and Mikkabi are rather archaic.

Supraacetabular fossa

A marked development of this fossa was first observed by BOUL (1911-13) in Neanderthals. This fossa is more developed in the Erectus stage as seen in Table 4. Its development also shows that Akashi is modern while Minatogawa I and Mikkabi are somewhat archaic. The presence of this fossa influences the shape of the profile of the vertical iliac buttress

as shown in Fig.5. Only Akashi is also modern in this respect.

Structures in general

Judging from all the structures listed in Table 4, it is concluded that the all Japanese specimens are in the Sapiens stage and Akashi seems very modern. No characters indicating the earlier stage can be seen in the case of Akashi innominate bone.

FORM IN DETAIL

Detailed metrical characters

For further objective comparison in detail, a series of metrical methods was developed as shown in the explanation of Fig.6. Measurements were carried out on fossil specimens and on twelve Recent Japanese specimens.

The results thus obtained are shown in Tables 5 and 6. The inclinations of the

Fig.5. Profiles of the ridge of the vertical iliac buttress. Setting the plane of the acetabular brim vertically and the vertical buttress horizontally, the profile of the buttress is drawn from the lateral corner of the tubercle of crest (TC'), along the ridge of the buttress, to the edge of the acetabular brim (AB) by means of the diagraph.

Fig.6. Measurements of the ilium.

Setting the iliac blade horizontally, outlines of the ilium are plotted by the perigraph and the following points for measurement are projected by the diagraph onto a sheet of paper.

TC: The point on the tubercle of the crest at which the ridge of the crest and the extension of the ridge of the vertical iliac buttress (VIB) intersect with each other.

AS: Center of the anterior superior spine.

AS': Foot of the perpendicular from AS on the extension of DIN-DSN line.

DIN: Deepest point of the interspinous notch.

NIN: The point on the interspinous notch nearest to the greater sciatic notch.

AI: Center of the anterior inferior spine.

SAB: Superior corner of the acetabular brim.

CA: Center of the acetabulum.

PAB: Posterior corner of the acetabular brim.

PS: Center of the posterior superior spine.

PS': Foot of the perpendicular from PS on the extension of DIN-DSN line.

PI: Center of the posterior inferior spine.

AU: Auricular point; a point of intersection of the arcuate line with the margin of the auricular surface.

SSN: Superior corner of the greater sciatic notch.

DSN: Deepest point of the greater sciatic notch.

NSN: The point on the greater sciatic notch nearest to the interspinous notch.

NSN': The point on the greater sciatic notch nearest to the acetabular brim.

H1, H2, H3, H4: Highest points on the iliac crest measured from the lines of AS-PS,

AS-PI, DIS-DSN, AI-PI respectively.

VIB: Outer ridge of the vertical iliac buttress.

The simplified shape of the heptagon consisting of connecting lines of TC-AS-DIN-DSN-PI-PS-H3-TC indicates the general shape of the iliac blade and connecting lines of AI-AU-SAB-SSN forms a Z-shaped datum.

Measurements listed below are executed on the paper or directly on the specimen.

i. Height of iliac blade. Length of perpendicular from H3 to DIN-DSN line. Measured on the paper.

ii. Projected width of iliac blade. Distance between AS' and PS' measured on the paper.

iii. Width of iliac blade base. Distance between NIN and NSN.

iv. Width of iliac blade base. Distance between AI and NSN.

v. Acetabulo-auricular length. Smallest distance between AU and the articular surface of the acetabulum.

vi. Thickness of ischial body. Distance between PAB and NSN'.

vii. Inclination angle of VIB to AI-AU line. Measured on the paper.

viii. Inclination angle of VIB to SAB-SSN line. Measured on the paper.

ix. Inclination angle of VIB to SAB-AU line. Measured on the paper.

x. Inclination angle of VIB to DIN-DSN line. Measured on the paper.

xi. Angle between TC-AS line and DIN-DSN line. Measured on the paper.

xii. Lateral cant angle between AI-axis and AI-AS ridge. Angle between the longest axis of the anterior inferior spine and the line connecting AI and AS. Measured in the frontal plane.

xiii. Lateral cant angle between AI-axis and VIB. Measured in the frontal plane.

xiv. Lateral cant angle between plane of greater sciatic notch and VIB. Angle between the plane formed by the greater sciatic notch and the line of VIB. Measured in the frontal plane.

Table 5. Detailed metrical characters of the innominates of fossil hominids obtained by the methods developed for the present study.

Item	Australopithecus Sts 14	Erectus OH 28	Erectus Arago	Neanderthal Düsseldorf
i. Height of Iliac Blade (H3 to DIN-DSN Line)	72	(108)	108	102
ii. Projected Width of Ilium (AS'-PS')	110	173	185	171
i : ii. Height-Width Index of Iliac Blade	65	62	58	60
iii. Width of Iliac Blade Base (NIN-NSN)	45	68	73	72
iv. Width of Iliac Blade Base (AI-NSN)	44	69	73	71
iii : 12. Index of Constriction of Iliac Blade Base	42	39	39	42
v. Acetabulo-auricular Length	38	47	63	64
vi. Thickness of Ischial Body(PAB-NSN')	22	36	38	38
vii. Inclination Angle of VIB to AI-AU Line	117	110	109	96
viii. Inclination Angle of VIB to SAB-SSN Line	119	105	108	97
ix. Inclination Angle of VIB to SAB-AU Line	104	101	101	88
x. Inclination Angle of VIB to DIN-DSN Line	155	136	134	126
(vii+viii+ix)/3. Average Inclination Angle of VIB	113	105	106	95
xi. Angle between TC-AS Line and DIN-DSN Line	(115)	(90)	90	(72)
xii. Lateral Cant Angle between AI-Axis and AI-AS Ridge	10	(45)	50	(40)
xiii. Lateral Cant Angle between AI-Axis and VIB	5	(35)	50	40
xiv. Lateral Cant Angle between Plane of G.Sciatic Notch and VIB	20	30	25	15

vertical iliac buttress along the sagittal plane and along the frontal plan as shown in Fig.4 are thus measured. The relationships of the lateral cant or inclination of the anterior inferior iliac spine and the anterior border of the iliac blade are schematically shown in Fig.7. The anterior border is strongly inclined in the Australopithecus and Erectus stages, while it is rather erected in the Sapiens stage. In the case of Akashi it is extraor-

dinarily erected. On the other hand, the strong inclination of the inferior spine is limited in the Australopithecus stage. Markedly changed characters along the progress of the evolutionary stage are shown in Fig.8.

All these metrical characters indicate that Minatogawa I is intermediate between Neanderthal and Sapiens whereas Akashi is modern.

Statistical analysis

Table 6. Detailed metrical characters of the innominates from Japan obtained by the methods developed for the present study.

Item	Pleistocene			Recent Japanese (ⁿ ^s M)
	Minatogawa I	Mikkabi	Akashi	
i. Height of Iliac Blade (H3 to DIN-DSN Line)	(92)	—	(88)	12 6.1456 98.3
ii. Projected Width of Ilium (AS'-PS')	154	—	124	12 8.8506 146.2
i : ii. Height-Width Index of Iliac Blade	60	—	71	12 3.7979 67.3
iii. Width of Iliac Blade Base (NIN-NSN)	70	67	62	12 3.9158 70.7
iv. Width of Iliac Blade Base (AI-NSN)	70	67	62	12 4.2817 70.8
iii : 12. Index of Constriction of Iliac Blade Base	45	—	49	12 1.8990 46.8
v. Acetabulo-auricular Length	56	45	41	12 5.7281 48.5
vi. Thickness of Ischial Body (PAB-NSN')	37	33	27	12 1.8505 35.8
vii. Inclination Angle of VIB to AI-AU Line	93	94	91	12 7.1026 92.6
viii. Inclination Angle of VIB to SAB-SSN Line	97	98	93	12 8.0731 95.1
ix. Inclination Angle of VIB to SAB-AU Line	83	80	79	12 8.7108 83.7
x. Inclination Angle of VIB to DIN-DSN Line	122	122	116	12 5.4160 120.7
(vii+viii+ix)/3. Average Inclination Angle of VIB	91	91	88	12 7.8291 89.8
xi. Angle between TC-AS Line and DIN-DSN Line	71	(75)	80	12 4.7673 74.0
xii. Lateral Cant Angle between AI-Axis and AI-AS Ridge	30	(30)	-5	12 88.227 33.8
xiii. Lateral Cant Angle between AI-Axis and VIB	30	(25)	20	12 5.2764 28.8
xiv. Lateral Cant Angle between Plane of G. Sciatic Notch and VIB	10	(13)	13	12 5.4523 11.5

The sizes of the fossil hominid innominates are various. The results hitherto described, however, are rather related to the shape. Therefore, it becomes important to observe the pure shape. For this reason it is desirable to use metrical characters without dimension, such as index and angle.

In order to distinguish the evolutionary stages, four from such characters are

selected for the multidimensional scaling. They are 9 : 12 from Table 1 and i : ii, iii : 12, and x from Table 5 and 6. OH-28 is omitted from this treatment, because it has inaccurate value of 9 : 12.

The results thus obtained are shown in Fig. 9. *Australopithecus* and *Erectus* are far from *Sapiens* and the former is farther. On the other hand, the Neanderthal is close to *Sapiens*.

Fig.7. Scheme of various lateral cants of the anterior border of the iliac blade. AS,anterior superior spine; AI,anterior inferior spine; SAF, supraacetabular fossa; CAB, center of acetabulum.

Fig.8. Evolutional change of main part of metrical characters used in the present study.

Fig.9. Two-dimensional demonstration of the results obtained from the multidimensional scaling computation using the Euclidean distances calculated from four non-dimensional characters (9:12, i:ii, iii:12, and x, cf. Table 1 and Tables 5 and 6). + indicates the mean position of the twelve Recent Japanese.

Of Japanese fossil specimens, Minatogawa I is somewhat shifted like Düsseldorf toward the position of the Erectus, but Akashi is shifted inversely. All in all, both the specimen seems to fall within the region of the Sapiens.

TWO-DIMENSIONAL SHAPE OF ILIAC BLADE

Simplification of shape

From the measurements described in Fig.6, the simplified two-dimensional shape of the iliac blade can be drawn on the specimens used in the present study, as shown in Fig. 10. Differences of Australopithecus and Erectus from other specimens seem clear.

Next, the size of these figures is made nondimensional in order to obtain the

pure shape. This is executed by dividing each length of members of the heptagon by the value of $i+ii$ in Tables 5 and 6. Using the mid-point between DIN and DSN as the common origin, these figures are so oriented that the DIN-DSN line becomes horizontal. The figures thus drawn are shown in Fig.11.

Comparison of simplified shape

The top of this figure shows the successive change in shape of the iliac blade from the Australopithecus stage to the Sapiens stage. The middle compares Akashi and Minatogawa I with Neanderthal and an example of Sapiens. It shows that these two are rather similar to Sapiens. The bottom compares them with six examples of Recent Japanese, indicating that there is almost no difference.

Fig.10. Comparison of the form of the iliac blade by means of the simplified heptagon.

1 to 4 indicate H1 to H4 explained in Fig.6. For other explanations see also Fig.6.

Statistical analysis

Fig.11 seems to show clear facts, but it is still insufficient, because the distribution due to variation of *Sapiens* is not observable. For further analysis, each position of intersection was measured

based on the two-dimensional coordinate system consisting of the horizontal and vertical axes having the origin at the mid-point between DIN and DSN. The data of two-dimensional positions are used again for the multidimensional scal-

ing.

The results obtained are shown in Fig. 12. They are fairly similar to the results

shown in Fig. 8. Akashi is located within the distributed area of Sapiens, whereas Minatogawa I is located again in their peripheral area, being rather close to Neanderthal.

DISCUSSION AND CONCLUSION

Major evolutionary change

There are almost parallel tendencies in the evolutionary change of morphological characters of the ilium from the Erectus stage to the Sapiens stage, which are clearly indicated in Figs. 2, 3, 5, 7, 8, 9 and 12.

As for the Australopithecus stage, however, some characters fit well onto the extension of these tendencies, but the others do not, namely, lateral cant of the iliac blade, relative width of the blade, constriction of the blade base and so on. This rather peculiar feature of the Australopithecus ilium from the evolutionary point of view is also suggested by the peculiar position in the distribution diagrams of Figs. 9 and 12. Further studies are necessary to clarify this problem.

Japanese Pleistocene innominates

Based on his study on the morphological features of the Akashi innominate bone, HASEBE (1948) maintained that this bone must be of a man in the Erectus stage. His assertion depended on several characteristics observable in this specimen. However, these characteristics are all modern according to the present study except for the smallness. None seems archaic.

In the case of the Mikkabi innominate, SUZUKI (1962) pointed out some characters

Fig. 11. Comparison of the pure shape of the iliac blade represented by the nondimensionally simplified heptagon. Top, Australopithecus, Erectus, Neanderthal and Sapiens; middle, Minatogawa I and Akashi compared with Neanderthal and Sapiens; bottom, Minatogawa I and Akashi compared with six Recent Japanese.

Fig.12. Two-dimensional demonstration of the results obtained from the multidimensional scaling computation using the Euclidean distances calculated from the coordinate values of all the intersecting points of the heptagon. + indicates the mean position of the twelve Recent Japanese.

different from those of Akashi. According to the present study, they are rather archaic characters indicating a primitive Sapiens.

It can be concluded that the Akashi man is neither Erectus nor Neanderthal nor Pleistocene Sapiens. He is probably a Japanese of the historic age and could possibly be a modern Japanese. This morphological fact indicates that the stratigraphical doubts are valid.

The Minatogawa man is in all morphological respects an archaic Sapiens. Judging from not only the morphological facts but also the chronological facts (SUZUKI, 1982), he must surely be a Pleistocene Sapiens. It can also be considered from the morphological facts that the Mikkabi man is an archaic Sapiens. When

the stratigraphical facts (WATANABE *et al*, 1962) and the paleontological facts (TAKAI, 1962), as well as the results of the fluorine test (TANABE, 1962), are taken into consideration together with the morphological facts, the Mikkabi man must also be a Pleistocene Sapiens.

In the case of the Minatogawa man further detailed archaic characters can be seen in male and female, because innominate were well preserved in this case (BABA and ENDO, 1982).

ACKNOWLEDGMENT

The present authors express their sincere thanks to Professor de LUMLEY, for his permission to use the Arago innominate cast for comparison.

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(Received June 10, 1982)

Note 1. (from MASUYAMA, 1943)

Let a sample consisting of $x_1, x_2, \dots, x_m$ be from a population, where $x_m = (x_{m1}, x_{m2}, \dots, x_{mk})$.

Let $S_{ij} = \sum_{m=1}^n (x_{mi} - \bar{x}_i)(x_{mj} - \bar{x}_j)$ and

$$[S_{ij}]^{-1} = [T_{ij}].$$

The equation for test of the specimen x_o is

$$F_{obs} = \frac{(N-k)N}{k(N+1)} \sum_{i=1}^k \sum_{j=1}^k T_{ij} (x_{oi} - \bar{x}_i)(x_{oj} - \bar{x}_j),$$

where $df_1 = k$ and $df_2 = N - k$.

Note 2. (from FISCHER, 1958 and KISHINE, 1977)

Let a sample consist of $x_1, x_2, \dots, x_n$ and let

$$m_i = \sum_{j=1}^n (x_j - \bar{x})^i / n. \text{ Then let}$$

$$k_2 = \frac{n}{n-1} m_2, \quad k_3 = \frac{n^2}{(n-1)(n-2)} m_3,$$

$$k_4 = \frac{n^2 \{ (n+1)m_4 - 3(n-1)m_2^2 \}}{(n-1)(n-2)(n-3)}.$$

The cumulants are $g_1 = \frac{k_3}{k_2^{3/2}}$ and $g_2 = \frac{k_4}{k_2^2}$.

The variances of g_1 and g_2 are

$$\sigma_{g_1}^2 = \frac{6n(n-1)}{(n-2)(n+1)(n+3)} \text{ and}$$

$$\sigma_{g_2}^2 = \frac{24n(n-1)^2}{(n-3)(n-2)(n+3)(n+5)}.$$

Calculate z as

$$z_1 = \frac{|g_1|}{\sigma_{g_1}} \text{ and } z_2 = \frac{|g_2|}{\sigma_{g_2}}.$$

Read probabilities of p_1 and p_2 from normal distribution table at z_1 and z_2 respectively. Let α be the level of significance.

If $p_1 > \alpha$ and $p_2 > \alpha$,

the sample is normally distributed.

*Many researchers regard this fossil as a precursor of the European Neanderthal. The term *Homo erectus* is used in a wide sense in the present paper.

日本更新世人寛骨の形態学的研究

——とくに明石人寛骨を含めて——

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日本における更新世人類の化石は少なく、しかも近年発見された港川人の場合を除けば、さまざまな骨の破片が大部分である。しかし、寛骨については、明石（♂左）、三ヶ日（♂左）、浜北（♀右）の各一側と港川4個体（♂1個体、♀3個体）の両側を数えることができる。浜北は残存部が小さ過ぎるが、他は少くとも腸骨について他の人類とあるいは相互の形態学的比較検討が可能である。また明石と港川については、少くとも腸骨の全貌を推察することができる。他方、現在ではアフリカやヨーロッパで *Australopithecus*, *Erectus*, *Neanderthal* の各段階の寛骨が発見されていて、その模型が入手可能となっている。これらも同様に、少くとも腸骨の全貌を推察しうるものである。

このような状況において、観察の対象となりうる男性寛骨、明石、三ヶ日、港川Iを更新世化石寛骨模型および現代日本人寛骨と比較し、それらの形態学的特徴を明らかにすることを試みた。なお明石についてはその包含層について疑問が多い（渡辺, 1970）。

比較資料として、化石寛骨には Sts-14 (*Australopithecus*) OH-28 (*Erectus*), Arago (*Erectus*), Düsseldorf (*Neanderthal*) の模型を、現代日本人には東京大学総合研究資料館および独協医科大学所蔵の男性寛骨左側12個体を用いた。また計測値比較資料として、宮本 (1927) の現代畿内日本人資料と田幡 (1928) の津雲縄文時代人資料を用いた。

上記の化石寛骨模型および日本更新世人寛骨からあらたに黄色石膏によるレプリカを作成し、欠損部は白色石膏で補って復原した。これは先に述べた腸骨全体の形を推察するとともに、ともすれば古さを強調するように見える原標本の色調によって生じやすい観察の片寄りを防ぐためである。

上記の全標本を通観すると、日本の更新世人の寛骨はいづれも現代日本人に最も類似する。すなわち、すべて *Sapiens* に属すると考えられる。

ここで、通常の計測法により可能な計測値と現代畿内日本人の同種の計測値を統計的に比較する。方法は畿内人をベクトル母集団とし、日本更新世人と津雲縄文人5個体の計測値ベクトルを棄却検定（増山1943）することによる。結果は Table 3 の通りである。全津雲人と明石人は棄却されず現代日本人母集団に属している。少くとも完新世日本人といえる。これに反し、港川人Iは完全に棄却され他の集団に属することがわかる。同じ計測項目について畿内人の標準偏差をもちいた Shape distance で畿内人30個体、津雲縄文人5個体、明石人、港川人Iの行列を作り、これに多次元尺度法を適用する。結果は上記のものにほぼ等しく、しかも明石人は港川人Iとかけ離れていることがわかる (Fig.1)。

寛骨の表面に観察できる諸特徴は Figs. 2, 3, 5, 7, Table 4 の通りである。これらには進化段階と平行して変化する特徴が多く、それらから判断すると港川I、三ヶ日は *Neanderthal* 的な古い *Sapiens* と考えられるが、明石は現代的である。

ここで詳細な計測法を設定して適用してみる。そのなかから無名数値を選んで形状を比較する。この場合は個体間ユークリッド距離にもつづく多次元尺度法を適用する。結果は Fig. 9 に見られるように港川Iは化石人類的で明石は現代人的であることを示している。

腸骨の形状を単純化 (Fig.6 参照) して7角形とするとFig.10 のようになるが、これを無名数化して比較すると Fig.11 のように明石も港川Iも *Sapiens* 的である。これらに共通原点を与えて7角形各頂点および交点座標値を測り、ユークリッド距離による多次元尺度法を適用しても、結果 (Fig.12) は今迄と同じく、明石は新しく港川は化石人的になる。

結局、明石人寛骨は縄文以降現代までのいずれかの時代の日本人寛骨であり、港川Iと三ヶ日の寛骨は更新世 *Sapiens* の寛骨と考えるのが妥当である。