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Morphology of the Fossil Hominid Tibia from Sambungmacan, Java

By

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Abstract In 1977 a hominid tibial fragment (Sm 2) was collected (not *in situ*), together with other vertebrate bones, from Sambungmacan. The bone has heen inferred to be derived from the Kabuh equivalent layer. The fragment is a lower shaft of the right tibia, black in colour and well-fossilized. The total length was estimated as about 37 cm, comparable to that of Solo B. In diameters (32.0 mm and 21.2 mm) and flatness (66.3) of the mid-shaft, it is close to East Asian Neolithic males, apart from Solo A and B and Zhoukodian (Choukoutien), and completly different from European Neandertals and Upper Palaeolithic Sapiens. However, the cortex is extremely thick and the medullary cabity is very narrow, resembling the condition of the limb bones from Zhoukoudian. As a whole, this tibial fragment shows rather advanced character in spite of its old chronological age.

Introduction

In September 1977, a geological survey was conducted under the Indonesia-Japan Joint Research Projiect CTA-41 (WATANABE & KADAR ed., 1985) supported by Japan International Cooporation Agency (JICA), at the Solo River short-cut site near Sambungmacan, where a skull cap like Ngandong skulls was found in 1973 (JACOB, 1975). Fossil vertebrate bones were collected and part of the specimens were submitted to Dr. S. MATSU'URA, one of the members of the Project, in the National Science Museum, Tokyo (now in Ochanomizu University), for analysis of fluorine content. Preparing these bones, Dr. MATSU'URA recognized one fragment as a human tibia (Fig. 1). Then N. WATANABE, the third author of this paper and the head of Japanese team of the Joint Proiect, brought it back to Geological Research and Development Centre in Bandung. Later on we had started a study on this tibial fragment and made preliminary reports (BABA & AZIZ, 1989; AZIZ *et al.*, in press). In 1990 we met Prof. T. JACOB and got a suggestion from him to determine registration numbers as follows: Sambungmacan No. 1 (Sm 1) for the skull cap and Sambungmacan No. 2 (Sm 2) for the tibia in question.

According to MATSU'URA *et al.* (1998, 1990), the bone was not found *in situ*, but the degree of fossilization and the fluorine content of the specimen suggest that it was

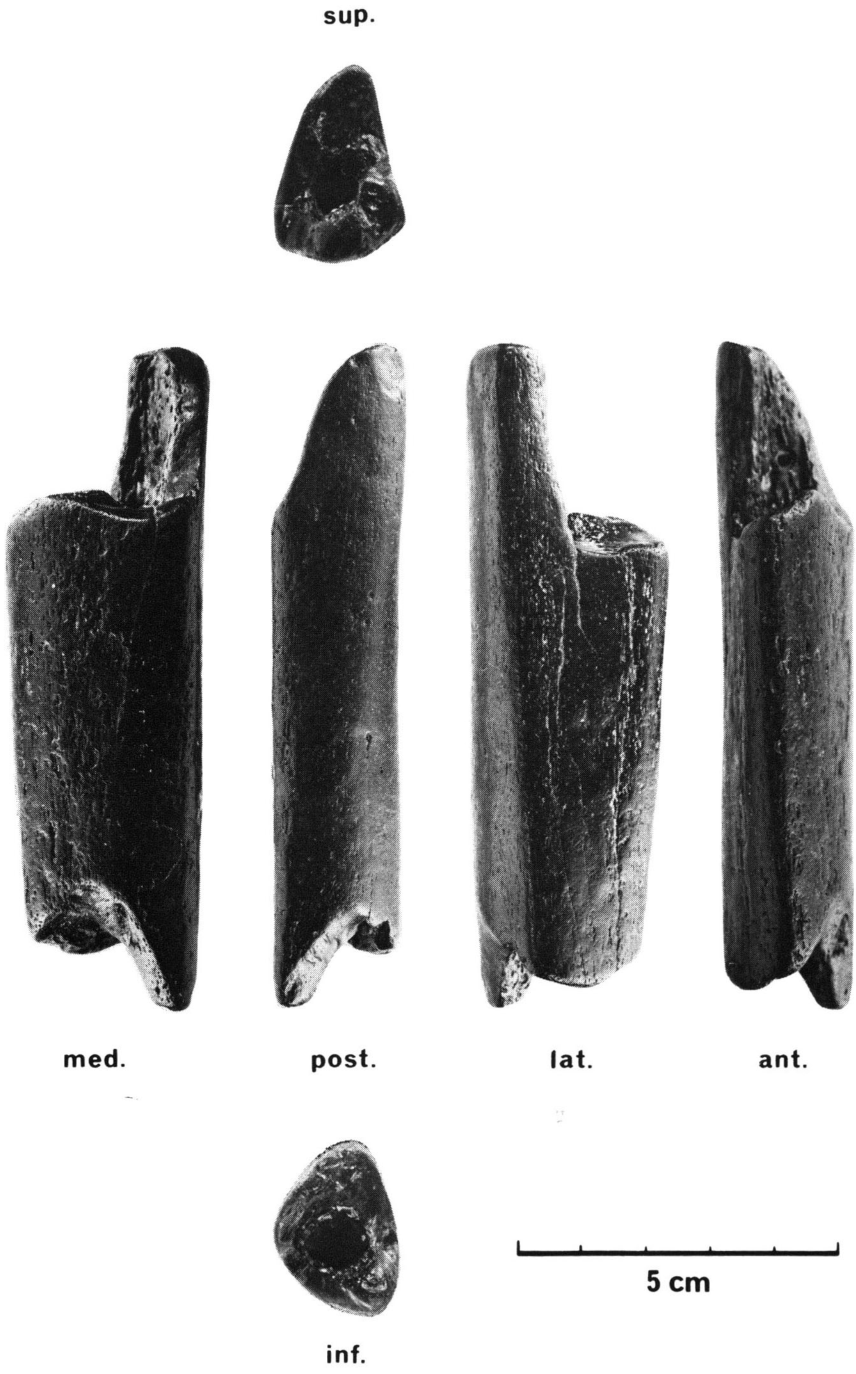

Fig. 1. Six views of the Sambungmacan tibial fragment.

derived from a lower part of the Kabuh equivalent layer at the site.

Description of the Tibial Fragment

Preservation

The specimen represents a lower region of the human right tibial shaft, 10.5 cm in length (Figs. 1, 2). The exact position of the fragment in the tibial shaft is not clear. However, the point A of the upper fracture in the Fig. 2 seems correspond to the mid-shaft or a little higher level, because the nutrient canal, which is invariably situated in the upper one third of the shaft, is not present on both the posterior surface and the upper fracture. In addition, the width is almost even in the remaining shaft. This means that the lower fracture is located at a distance from the lower epiphysis. Its colour is black to very dark brown. The whole surfaces including fractures are worn and polished. It is deeply mineralized and as hard as a stone. A few narrow cracks, probably made before fossilization, are seen in the upper region of the medial and lateral surfaces.

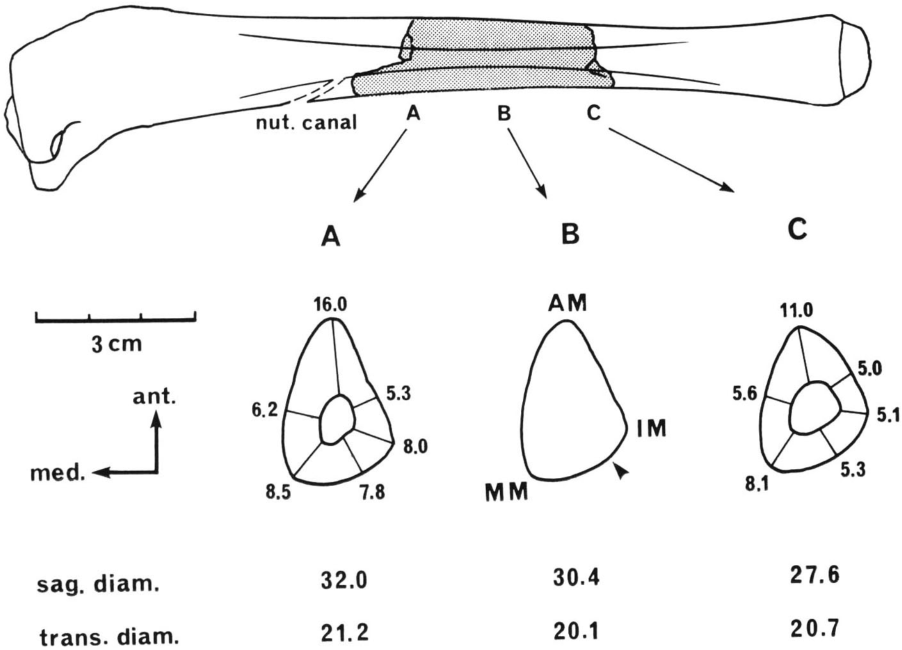

Fig. 2. Cross-sections of the sambumgmacan tibial fragment. Shadowed area corresponds to the remaining part of the bone. A, B and C indicate positions of the cross-sections. Thickness of the cortex is shown around the cross-sections at A and C. AM, anterior margin; IM, interosseous margin; MM, medial margin. An arrow head indicates the eminance dividing the muscle attachment of FD and TP in Fig. 3.

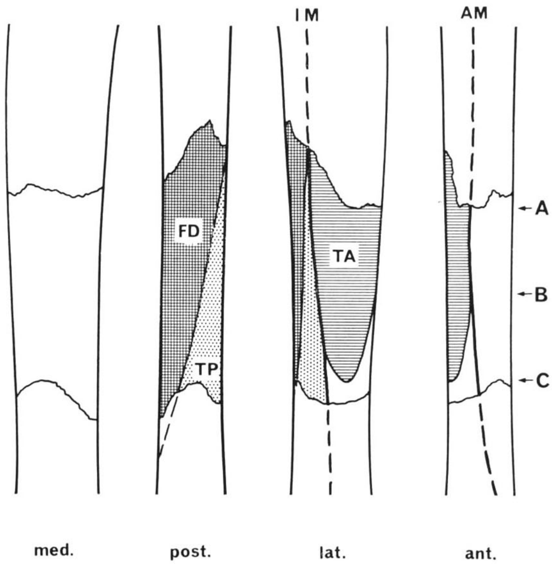

Fig. 3. Reconstruction of the surface structure of the Sambungmacan tibia. TA, attachment of the tibialis anterior muscle; FD, attachment of the flexor digitorum longus muscle; TP, attachment of the tibialis posterior muscle. For other abbreviations see Fig. 2.

Morphology

The shaft is flattened transversely and typically three sided (Fig. 2). The anterior margin is rather sharp but slightly worn. Its lower part is curved medially indicating the presence of the tendon of tibialis anterior, as is true in hominid tibia. The medial margin is worn but well-defined. It is straight and located at the posteromedial corner of the bone. The interosseous margin is rounded due to wearing. It is not straight; in its upper one third it runs vertically, paralled to the bone axis, then it turns anteriorly and runs down slightly obliquely to the bone axis, as is sometimes seen in recent tibiae (Figs. 1, 3).

The medial surface is moderately convex as is usual in hominid tibia. Most of the lateral surface (except its lower end) is slightly concave showing impression by the tibialis anterior muscle. The posterior surface is somewhat convex but not bulged, which means that the medial and interosseous margins are located relatively posteriorly. This surface is devided into two parts; superomedial and inferolateral ones demarcated by a low obtuse eminence running in a superolateral to inferomedial direction (Fig. 3). The former part should correspond to the area of the flexor digitorum longus muscle and the latter to that of the tibialis posterior muscle.

Metrics

The shaft decreases its maximum sagittal diameter downwardly. It measures

32.0 mm at the upper fracture (point A in Fig. 2), 30.4 mm at the middle part of the fragment (point B), and 27.6 mm at the lower fracture (point C). On the other hand, its tranverse diameter is almost even in throughout the remaining shaft. It is 21.2, 20.1, and 20.7 mm at the points A, B, and C respectively. The original diameters of the intact tibia should have been somewhat (c. 1 mm) larger than the present ones, since the surfaces were worn. The circumference measures 86, 81 and 76 mm at points A, B and C respectively.

The shaft is flattened transversely having a cross-sectional index of 66.3. The cortex of the shaft is extremely thick, being 5.3–16.0 mm at the upper fracture and 5.0–11.0 mm at the lower fracture (Fig. 2). With this thickening of the cortex the medullary cavity is very narrow, 9×7 mm at the upper fracture.

Discussion

Overall length

Comparing with tibiae of recent and Neolithic (Mesolithic) Japanese and recent Asiatic Indian, we roughly assessed an original total length of the intact tibia at 37 cm or slightly longer (35–40 cm). This assessment was based not only on the general shape and size of the bone but on the fact that there could not be seen any nutrient canal around the upper fracture. This length falls in the middle of the range of the male tibiae from middle to late Pleistocene and is larger than those of the females (Table 1). It also surpasses the means of the Neolithic and recent male tibiae from China and Japan (Table 1).

However, the Solo B tibia, which was considered as of female by WEIDENREICH (1951), has a physiological length of 348 mm (SANTA LUCA, 1980) and a total length of 365 mm (OPPENOORTH, 1937), being almost equal to that of the Sambungmacan. In addition, according to our direct comparison of the specimens, the Solo A tibia, which was considered as of male by WEIDEREICH, is much longer. It is very difficult for us to determine the sex of the specimen, but we tentatively regard this tibia as of male.

Cross-section at mid-shaft

In the Sambungmacan tibia the cross-section at mid-shaft is typically triangular in shape, corresponding to HRDLIČKA's (1920) type 1 or 2, which is common in recent humans such as Indonesian and Japanese, but quite rare in fossil hominids, most of which have a rounded anterior margin and a bulged posterior surface (Fig. 4). In general, diameters of human tibial mid-shaft are larger in Europe, Africa, and West Asia than in East Asia regardless of evolutionary stage (Table 1). The Sambungmacan tibia has sagittal and transverse diameters of 32.0 and 21.2 mm respectively, which are close to those of Neolithic and recent East Asian males and far surpass those of the females (Table 1). However, if we compare them with those of the Solo tibiae, the diameters are slightly larger than in Solo B and much smaller than in Solo A.

Tabel 1. Comparison of Metrical Data of Tibia (mm, %)

stage individual or population	side, sex	total length	sagitt. diam. at mid.	trans. diam. at mid.	cr. -sec. index at mid.
Sambungmacan	r, m ?	35–40 cm	32.0	21.2	66.3
Erectus					
Zhoukoudian	l, –	–	27.0	21.0	77.8
Erectus-Neandertal					
Solo A	r, m	–	37.1	27	73
Solo B	r, f	c. 365	29.5	21.2	71.9
Broke Hill	l, m	409	34	24	71
European Neandertal					
Spy II	l, m	331	33	23	70
La Ferrassie 1	r, m	c. 365	36.7	23	63
La Ferrassie 2	r, f	c. 295	28	21	75
W. Asian Neandertal					
Amud 1	l, m	384	39	25	64
Shanidar 1	l, m	c. 350	34.0	25.8	75.9
Shanidar 2	l, m	325	35.7	25.4	71.1
Shanidar 6	l, f	c. 295	29.5	21.3	72.2
Tabun I	r. f	315	27.0	20.0	74.1
Palaeolith. Sapiens					
Skhul III	l, m	405	35.0	23.0	65.7
Skhul IV	r, m	430	32.0	25.0	78.1
Skhul V	l, m	412	39.0	26.5	67.9
Cro-Magnon 1	r, m	410	45	27	60
Obercassel	r, m	403	39	24	62
Minatogawa I	r, m	c. 318	27	19	70
Minatogawa III	r, f	298	26	17	65
Minatogawa IV	r, f	c. 297	23	16	70
Neolith. Sapiens					
Yan-Shao-Tsun	r, m	364	32.6	21.8	66.9
(China, n=5)	r, f	337	28.1	20.3	72.2
Tsukumo*	r, m	346	32.1	19.6	61.5
(Japan, n=19)	r, f	318	26.8	17.7	65.4
Sanganji*	r+l, m	339	31.1	21.0	67.6
(Japan, n=22)	r+l, f	322	26.6	19.0	71.7
Recent Sapiens					
Fukien Chinese	r, m	348	28.2	22.1	78.1
(n=78)	r, f	315	22.0	17.7	81.0
Kinai Japanese	r, m	327	28.5	21.0	74.2
(n=30)	r, f	301	24.0	18.7	78.0

Zhoukoudian, WOO & CHIA 1954; Solo, SANTA LUCA 1980 & OPPENOORTH 1937; Broken Hill, PYCRAFT 1928; Spy, FRAIPONT & LOHEST 1887; La Ferrassie, HEIM 1976; Amud, ENDO & KIMURA 1970; Shanidar, TRINKAUS 1983; Tabun & Skhul, MCCOWN & KEITH 1939; Cro-Magnon, BROCA 1868; Obelcassel, BONNET 1919; Minatogawa, BABA & ENDO 1982; Yan-Shao-Tsun, BLACK 1925; Tsukumo, KIYONO & HIRAI 1928; Sanganji, BABA 1988; Fukien Chinese, KOH 1942; Kinai Japanese, HIRAI & TABATA 1928. * hunter-gatherers, sometimes called Mesolithic.

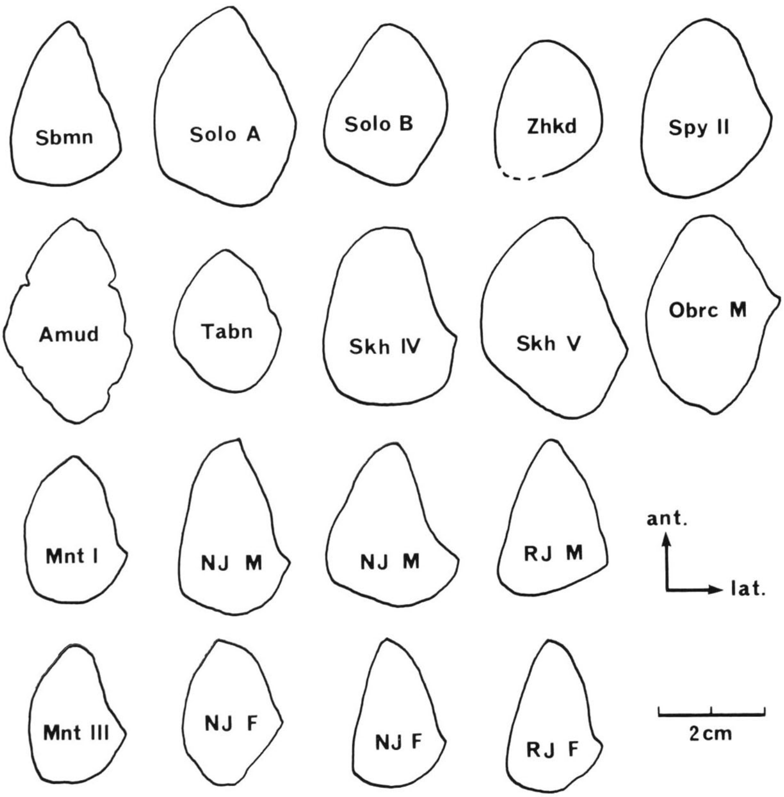

Fig. 4. Comparison of the cross-sections at mid-shaft. In left tibiae, figures are reversed. From top, left to right. Sambungmacan, Solo A, Solo B, Zhoukoudian (slightly lower than mid-shaft), Spy II; Amud I, Tabun I, Skhul IV, Skhul V, Obercassel Male; Minatigawa I, Neolithic (Mesolithic) Japanese Male (two casses), Recent Japanese Male; Minatogawa III, Neolithic (Mesolithic) Japanese Female (two cases), Recent Japanese Female.

Flatness of shaft

The Sambungmacan tibial shaft is somewhat flattened having a cross-sectional index of 66.3 at the middle. This value is greater than those of typical flat tibiae in European upper Palaeolithic people, comparable to those in Neolithic Japanese and Chinese, and smaller than those in Erectus and typical Neandertals such as Zhoukoudian, Solo A and B, and Spy II (Table 1).

Thickness of cortex

The Sambungmacan tibia has an extremely thick cortex and a narrow cavity (Fig. 2). Namely, at the mid-shaft, the cortex occupies 71% of the shaft diameter in a sagittal plane and 67% in a transverse plane, which resemble the condition in Zhoukoudian (WEIDENREICH, 1939; WOO & CHIA, 1954; KENNEDY 1985) and Skhul

IV (McCOWN & KEITH, 1939). According to KIMURA (1966), a thicker cortex produces more resistence force to bending moment. Therefore, the Sambungmacan tibia can be very strong for its moderate external size.

Comparison with Solo and Zhoukoudian tibiae

In size, the Sambungmacan tibia is much smaller than Solo A and slightly larger than Solo B. In shape of the shaft cross-section, the Sambungmacan and the Solo tibiae are quite different from each other (Fig. 4).

Since we have obtained a cast of Sinanthropus tibia from Zhoukoudian (WOO & CHIA, 1954), we can directly compare the two tibiae from South east Asia and East Asia. WOO & CHIA considered that the upper fracture of the Zhoukoudian tibia corresponded to the mid-shaft and measured the mid-shaft diameters there. However, the facts that the outline at the lower fracture of the Sambungmacan tibia resembles that of the upper fracture of the Zhoukoudian tibia (Figs. 2, 4), and that the cortex of the upper fracture of the Zhoukoudian is very thick, being close to that of the upper fracture of the Sambungmacan led us to conclude that the upper fracture of the Zhoukoudian should correspond not to the mid-shaft (point A in Fig. 2) but to a somewhat lower part (near point B). We assessed its sagittal diameter at mid-shaft as about 30 mm. Therefore, the shape and size of the cross-section at mid-shaft of the Zhoukoudian may resemble, in some degree, those of the Sambungmacan.

Conclusion

The Sambungmacan tibia is medium in size for a male, and has a thick cortex resembling that in the Sinanthropus. Although the specimen is probably derived from a lower part of the Kabuh equivalent layer, a considerable degree of shaft flatness and a triangular cross-section at middle indicate advanced features. Therefore, its position in the evolutionary stages is still unknown.

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