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Further new hominin fossils from the Kibish Formation, southwestern Ethiopia

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ABSTRACT

In addition to the new fragments of the Omo I skeleton, renewed fieldwork in the Kibish Formation along the lower reaches of the Omo River in southwestern Ethiopia has yielded new hominin finds from the Kibish Formation. The new finds include four heavily mineralized specimens: a partial left tibia and a fragment of a distal fibular diaphysis from Awoke's Hominid Site (AHS), a parietal fragment, and a portion of a juvenile occipital bone. The AHS tibia and fibula derive from Member I and are contemporaneous with Omo I and II. The other specimens derive from Chad's Hominid Site (CHS), and derive from either Member III or IV, which constrains their age between ~8.6 and ~104 ka.

Introduction

Recent fieldwork in the Kibish Formation, located in the Omo Basin of southwestern Ethiopia, has been fruitful in many regards. In addition to securing a radiometric date of 195 ± 5 ka for Member I of the Kibish Formation (McDougall et al., 2005; Brown and Fuller, 2008), and adding new elements to the Omo 1 partial skeleton originally recovered in 1967 (Fleagle et al., 2003; Pearson et al., 2008), a few new hominin localities were also discovered. Here, we report on the new hominin fossils and localities from the Kibish Formation. The new Omo Kibish specimens include cranial (parietal, occipital) and postcranial (tibia, fibula) fragments from two or three individuals.

Awoke's Hominid Site

Awoke's Hominid Site (AHS) was first discovered in 2003 by Ato Awoke Amzaye. The site is in Member I of the Kibish Formation (Brown and Fuller, 2008), and thus fossils recovered here are broadly contemporaneous (~195 ka) with Omo I, a partial skeleton from the KHS locality (Leakey, 1969; Butzer, 1969; Day, 1969; Day and Stringer, 1991; Day et al., 1991; Pearson et al., 2008). To date, AHS has yielded two hominin fossils, a heavily mineralized partial left tibia (Kib 158-1a) and a distal fragment of a fibula (Kib 158-1b), both from the surface. An extensive collection of bones and artifacts were recovered from an excavation that was conducted at the (see Assefa et al., 2008; Shea, 2008)

AHS tibia

The Kib 158-1a fossil is a well-preserved left distal tibia that preserves its shaft to a level just proximal to the nutrient foramen (Figs. 1–3). The tibia lacks a 64.3-mm-long portion of anterior wall of the distal shaft. It belongs to an adult individual, as there is no trace of the distal epiphyseal fusion line. The maximum length of the preserved fragment is 349 mm; the lengths from the nutrient foramen to the middle of the talar articular surface and to the distal tip of the medial malleolus are 260 mm and 275 mm, respectively. Estimates of the stature of this individual are possible based on these measurements. Assuming that the nutrient foramen is positioned at 75% of total tibial length, the preserved length of 275 mm yields an estimate of 366.7 mm as the maximum length of the complete bone. The predicted stature based on a tibia of this length is 166.4 ± 3.94 cm (based on African-American males) and 162.6 ± 3.7 cm (based on African- American females) (Trotter, 1970, in Steele and Bramblett, 1988). Alternatively, if the nutrient foramen is positioned at 67% of maximum length, we estimate total tibial length as 410.4 mm. Using this longer estimate of maximum tibial length predicts the stature of this individual at 176.2 ± 3.94 cm and 174.0 ± 3.7 cm for African-American males and females, respectively. Wright and Vásquez (2003) presented a series of formulae for long-bone lengths based on segments of the long bones, including two sets of segments preserved in Kib 158-1a (from the nutrient foramen to the distal tip of the malleolus and the center of the talar articular surface, respectively). These formulae

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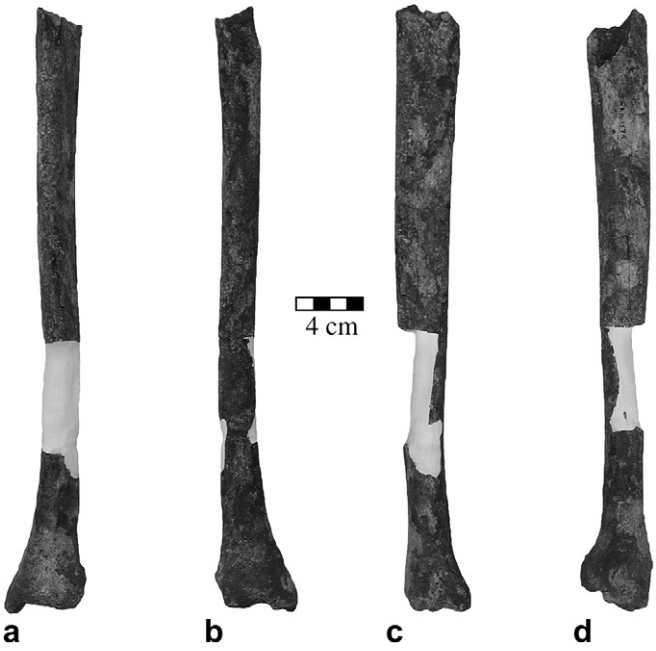

Fig. 1. Kib 158-1a, left tibia: (a) anterior view; (b) posterior; (c) lateral; (d) medial. Scale bar = 4 cm.

generate length estimates of 413.1–413.5 mm for the complete bone and possibly a slightly taller range of stature. However, Wright and Vásquez's (2003) formulae are based on forensic cases of recent Guatamalan Mayan Indians, which necessitates caution in applying them to individuals who likely have different body proportions. Regardless of which estimate of stature one accepts, the AHS tibia apparently belonged to a somewhat shorter individual than Omo I (Pearson et al., 2008), but comparable in stature to early modern females from Israel such as Skhul II, VII, and Qafzeh 9 (McCown and Keith, 1939; Vandermeersch, 1981).

In anterior view, the tibial diaphysis has a slight sigmoid curvature with a medial concavity distally and a lateral concavity proximally. The anterior tibial crest is blunt and the interosseous line is weakly developed, taking the form of a blunt crest near the posterior fifth of the lateral side of the shaft. Between the anterior tibial crest and the interosseous line, there is a gentle depression on the lateral compartment of the shaft. Shaft diameters taken at various levels are noted in Table 1. The shaft dimensions at the level

Fig. 2. Kib 158-1a, left tibia, inferior view; anterior is toward the bottom. Scale bar = 4 cm.

Fig. 3. Kib158-1a, left tibia, cross section at the proximal break; anterior is toward the left. Scale bar = 4 cm.

of the nutrient foramen produce a cnemic index of 63.1 (i.e., mesocnemic), which falls just above the cutoff of 62.9 for platycnemic tibiae (Bass, 1987). Omo I has slightly more platycnemic tibial shafts (Pearson et al., 2008), but exact comparisons are difficult because none of the midshaft levels can be determined precisely. A natural break in the shaft 106.5 mm distal to the nutrient foramen affords a look at cortical thickness and cross-sectional shape at a level slightly distal to midshaft. Here, the medullary cavity is filled with a 2-mm-thick layer of mineral encrustations, and the shaft cross section is teardrop-shaped. The medullary cavity measures 13.6 mm anteroposteriorly and 13.2 mm mediolaterally. At this level, the cortical walls are thick anteriorly and posteriorly, but thinner medially and laterally (Table 2). This can be appreciated in Figs. 3. At the distal end, a shallow pit, most likely a squatting facet (Boulle, 2001), is observed on the anterior aspect of the shaft immediately superior to the talar articular margin. The pit measures 7 mm superoinferiorly by 17.5 mm mediolaterally. Although Omo I also preserves a distal tibial epiphysis, abrasion of the anterior face of its epiphysis above the distal articular surface has destroyed any chance of checking for a similar squatting facet (Pearson et al., 2008). The maximum dimensions of the distal epiphysis measure 36.1 mm anteroposteriorly by 46.7 mm mediolaterally. Unlike many of the postcranial elements from Omo I, the AHS tibia shows no sign of arthritic degeneration. The articular surface of the tibiotalar joint is nearly flat, with minimal parasagittal keeling.

AHS fibula

A fragment of distal fibular diaphysis (Kib 158-1b), most likely from the left side, was recovered adjacent to the tibia; the two bones may belong to the same adult individual. The fragment is heavily mineralized with a grayish-brown surface, while the exposed cortical bone is dark gray, similar to the Omo KHS fossils and Omo II. The total preserved length of this fibular fragment is 74.0 mm. There is a wedge-shaped chunk of reddish-brown sandy matrix adhering to the superior end of the specimen, obstructing some measurements and morphology. One side of the diaphysis

Table 1
Shaft dimensions of the AHS tibia (Kib 158-1a)

Tibial shaft level	AP diameter (mm)	ML diameter (mm)
Nutrient foramen	33.9	21.4
Slightly distal to midshaft[a]	28.6	21.7

[a] Taken at the natural break in the shaft, 106.5 mm distal to the nutrient foramen.

Table 2
Cortical thickness of the AHS tibia (Kib 158-1a)

Tibia cortical wall[a]	Cortical thickness (mm)
Anterior	9.2
Posterior	6.0
Medial	3.1
Lateral	3.4

[a] All cortical-thickness dimensions were taken at the natural break in the shaft, 106.5 mm distal to the nutrient foramen.

displays a relatively constant convexity and appears to correspond to the posterolateral side of the shaft, while the opposite side bears three crests and is most likely the anteromedial aspect of the shaft. One crest, likely the interosseous crest, extends the entire length of the fragment, beginning under the adhering matrix. This crest has a roughened, osteophyte-covered surface. The two other crests follow a spiral course around the shaft. The longer spiral crest extends into the area covered by the adhering matrix (approximately 40 mm in length is visible), tapering off near the opposite end of the fragment. The shorter spiral crest is 19.3 mm long, truncated by the shaft fracture, and does not extend into the matrix-covered area at the opposite end. Measured at the middle of the preserved piece, the shaft dimensions are 15.9 mm (maximum diameter) and 11.4 mm (minimum diameter). At this level, the longer spiral crest is quite projecting. At the end that is free of adhering matrix, the shaft is teardrop-shaped in cross section. The medullary cavity is filled with a cream-colored concretion. Here, the maximum and minimum shaft dimensions are 13.2 and 11.3 mm, respectively.

Chad's Hominid Site

Two cranial vault fragments (Fig. 4) were collected as surface finds from locality 170, also known as Chad's Hominid Site (CHS). The specimens were recovered along with numerous other bone fragments and artifacts, including bone harpoon fragments, in a talus slope on the side of a small hill on the west side of the Omo River. As discussed by Brown and Fuller (2008), the age of the CHS hominins is problematic. Chad's Hominid Site lies well above the KHS tuff (~172 ka), two associated harpoons have yielded calibrated ^{14}C dates of between 8,554 and 9,125 years before present (BP), and the underlying tuff at CHS has a chemical composition that partially resembles pumices from the Aliyo Tuff (~104 ka). The CHS hominins either derive from Member III or from Member IV, which caps the hill; the specimens date to between ~8.6 and ~104 ka (Brown and Fuller, 2008).

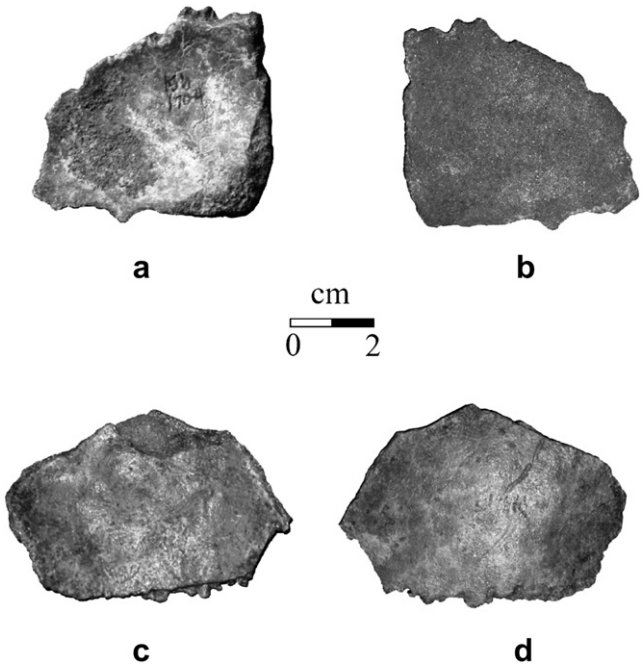

Fig. 4. Parietal and juvenile occipital fragments: (a) Kib 170-4, occipital, internal view; (b) occipital, external view; (c) Kib 170-1, parietal, internal view; (d) parietal, external view. Scale bar = 2 cm.

CHS parietal

Specimen Kib 170-1 represents a small posterior portion of a right parietal bone (Fig. 4c,d). The bone is orange-brown in color, with some grayish-brown stains. The fragment has a maximum length of 73.2 mm (along its anterior border) and a maximum width of 51.2 mm. The exposed diploë is generally quite thick, with vault thickness ranging between 8.3 mm and 9.3 mm. These measurements approximate the radiographically determined thickness at lambda of adult Australian Aboriginals from Yuendumu (Brown et al., 1979), as well as measurements taken 3 cm above lambda in images of African-American adult crania from emergency room radiographs taken in Cincinnati (Adeloye et al., 1975). Both the Australian and African-American measurements for cranial-vault thickness in this region slightly exceed the values recorded for European-Americans from the same city. Both Omo I and II have thick cranial vaults, with thickness at inion being greater than 14 mm and the parietals being 8 mm or greater in thickness (Day and Stringer, 1982, 1991). The adult early modern human crania from Herto have thick vaults (White et al., 2003); the Aduma and Bouri early modern crania have vault thicknesses ranging from an attenuated thickness like many recent humans (e.g., BOU-VP-5/1) to markedly thick (e.g., ADU-VP-1/1) (Haile-Selassie et al., 2004). Likewise, Qafzeh 5, 6, 7, and 9 have thicknesses at surrounding points (obelion, lambda, and asterion) similar to Kib 170-1; Qafzeh 3 is consistently thicker (Vandermeersch, 1981). This degree of thickness suffices to suggest that Kib 170-1 belonged to an adult.

A long stretch of the lambdoidal suture is preserved along one edge. Another side displays part of the superior temporal line, which coincides with a thinning of the diploë to 3.7 mm as the parietal approaches the squamosal suture. The internal aspect is marked by gently modeled, irregular undulations and bears few arterial impressions. There is no evidence to suggest that this specimen came from a juvenile individual, and thus the juvenile occipital specimen described below constitutes a second individual from the locality.

Bartsiokas (2002) conducted a macroscopic and histological investigation of small pieces of the parietal bones of Omo I from Member I of the Kibish Formation and an unpublished specimen designated as "Omo 1 (Howell)," which dates to the Holocene and derives from a locality called Pelvic Corner (Brown and Fuller, 2008). Using microscopy, Bartsiokas measured the ratio of cortex and diploë, finding that Omo I had a greater combined thickness of outer plus inner cortex relative to diploë, a trait characteristic of *H. erectus* rather than *H. sapiens*; Omo 1 (Howell) had a ratio characteristic of recent humans. Omo I also showed greater Haversian remodeling of the compact bone bordering the diploë than generally observed in recent humans. These observations led Bartsiokas to conclude that the anatomically modern gross anatomy of Omo I did not necessarily correspond to anatomically modern microanatomy or histology. A similar microscopic investigation of Kib 170-1 might be useful.

CHS juvenile occipital

Specimen Kib 170-4 is a juvenile occipital fragment from the right side of the cranium (Fig. 4a,b). The bone is grayish-brown both

internally and externally. On the internal surface, white and cream-colored patches are visible, as well as an area with thin adhering matrix, while the external surface bears a thin layer of sandy concretions. The specimen is well mineralized. There is evidence of a gently projecting external occipital protuberance in an area with thick bone (9.7 mm), and the specimen features exposed diploë and an impression laterally for the nuchal musculature. The external table of bone is quite thin. The internal surface displays both a weakly developed torus for the transverse sinus and a few arterial impressions. Laterally, there is no trace of an unfused sutura mendosa between the upper and lower portions of the pars squama, suggesting an ontogenetic age greater than 1 year, although in rare cases (10% of individuals), the suture can persist until 5–6 years or even later (Scheuer and Black, 2000). A small portion of sutural digitations from the lambdoidal suture is preserved. The fragment is roughly triangular in shape, measuring a maximum length of 69.2 mm (superior-lateral), 52.7 mm (inferior) and 48.0 mm (medial) along its three edges; the vault thicknesses for the middle of each side are 3.7, 2.6, and 3.6 mm, respectively. These measurements for the thickness of the occipital are similar to those of Qafzeh 21, which has a dental age of approximately 3 years and an occipital thickness of 3 mm along its lambdoidal suture (Tillier, 1999). In contrast, Qafzeh 13 (a full-term fetus or neonate) has notably thinner bone (3 mm at the external occipital protuberance), and Qafzeh 10 (approximately 6 years old according to its dental age) and Qafzeh 9 (approximately 9 years old by dental age) have substantially thicker bone in their superior occipital squama (Tillier, 1999). Roche's (1953) data on the development of cranial thickness at lambda suggests a probable age for the individual of 2–4 years; this agrees with Tillier's (1999) data and probably provides a reasonable estimate of the child's ontogenetic age.

Discussion and conclusions

Additional fieldwork in the Kibish Formation has yielded new hominin finds comprising four new heavily mineralized specimens including a partial left tibia from Awoke's Hominid Site (AHS), a fragment of a distal fibular diaphysis, a parietal fragment, and a portion of a juvenile occipital bone. The fragmentary tibia and fibula derive from Member I of the Kibish Formation and thus can be confidently assigned a late middle Pleistocene to early late Pleistocene antiquity (McDougall et al., 2005; Brown and Fuller, 2008). The AHS tibia belonged to a medium- to large-sized individual (between 162.6 ± 3.7 and 176.2 ± 3.94 cm in height) and is notable for its weakly developed muscle markings. Two cranial fragments from locality 170 (CHS) are attributed to different individuals and most probably derive from Member III or IV of the Kibish Formation. One of the cranial fragments is a portion of a right parietal and, given its thickness, most probably belonged to an adult. The other cranial fragment is a much thinner fragment of an occipital of a juvenile most likely between 2 and 4 years in age.

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