A comparative Study of Frontal Bone Morphology Among Pleistocene Hominin Fossils Group: A Study on Eyasi Hominin (EH6) Frontal Bone

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Abstract

Features of the frontal bone and the supraorbital torus are conventionally used to distinguish fossil hominin groups. The study examines and measures five (5) morphological variables of EH-06, and then compares with published and unpublished data of the morphologies and measurements of eighteen (18) hominin remains from Africa, Asia and the Near East, dating from early- to late Pleistocene. Using a digital calliper, the morphological variables measured include: 1) supra orbital torus thickness (central and lateral), 2) minimum frontal breadth, 3) maximum frontal breadth, 4) biorbital chord, and 5) post orbital constriction index (calculated as: maximum frontal breadth x 100/bizygomatic breadth). The results indicate that EH-06 exhibits features of Homo erectus and archaic Homo sapiens, but more moving towards frontal morphological features of anatomically-modern Homo sapiens.

Keywords: Frontal bone, Morphology, Variation, Archaic Homo sapiens

Introduction

The early to late middle Pleistocene period (about 1.5-0.125 mya) in Africa is composed of hominin remains classified as *Homo erectus*, archaic *Homo sapiens* (now Homo rhodesiensis) and anatomically-modern *Homo sapiens*. Archaic forms of *Homo sapiens* first appear about 500,000 years ago (Grine et al.2009). The term covers a diverse group of skulls, which have features of both *Homo erectus* and modern-anatomically *Homo sapiens*. The brain size is larger than

early Pleistocene *Homo erectus* (Rightmire, 1989) and smaller than most modern humans, averaging between 1000-1200cc, and the skull vault is more rounded than in *H. erectus*. The skeleton and teeth are usually less robust than erectus, but more robust than modern humans. Many still have large brow ridges and receding foreheads and no chins (Klein 2009). However, there are no clear dividing line between late *Homo erectus*, and archaic and modern *Homo sapiens*, and many fossils between 500,000 and 200,000 years ago are difficult to classify as one or the other. However, several new species of these hominins are now recognized by some paleontologists, both inside and outside Africa e.g., *H. antecessor, H. heidelbergensis, H. helmei, H. rhodesiansis, H. neanderthalensis* (Rightmire, 1989).

The dividing lines that separate anatomically-modern *Homo sapiens* from archaic *Homo sapiens* are also not clear. Anatomically-modern Homo sapiens have an average brain size of about 1350 cc. The forehead rises sharply, eyebrow ridges are very small or more usually absent, the chin is prominent, and the skeleton is very gracile. The earliest known fossils of anatomically-modern humans such as the Omo remains from 195 kya (McDougal et al., 2005), *Homo sapiens idaltu* (Ethiopia) from 160 kya (White et al., 2003) and Qafzeh (Israel) remains from 90 kya (Grun et al., 2005) are recognizably modern humans. However, these early anatomically-modern *Homo sapiens* exhibit a mix of some archaic traits, such as moderate, but not prominent, brow ridges as well as modern features such as a shorter skull and higher vault (Brauer & Mabulla 1996).

In 2004, Manuel Dominguez-Rodrigo and Audax Mabulla found a hominin frontal bone (Eyasi Hominin 06, EH 06) in the Eyasi Basin, northern Tanzania (Figure 1 & 2). EH-06 was recovered from the surface of the gray sands in the upper unit of the Eyasi lake beds. The frontal bone was found in direct together with abundant fossils of small and big animals in association with a core and flake industry classified within the early Middle Stone Age tradition (Dominguez-Rodrigo et al., 2007). Electron Spin Resonance (ESR) dates Eyasi Hominin 06 (EH-06) to about 118,000 years BP to within the Middle Stone Age period. Morphologically, EH-06 is classified as an archaic Homo sapiens (Dominguez-Rodrigo et al., 2008).

However, the present age of EH-06 provides a younger chronological context for archaic *Homo sapiens* than recognized from previous specimens. If the age

is correct, EH-06 shows a continuation of archaic/primitive morphological features in a period that has yielded more substantially anatomically-modern *Homo sapiens* (eg., Omo remains, Herto remains, Border Cave remains, Qafzeh, Klasies River Mouth Cave, etc).

This study examines and discusses whether EH-06 morphologically and metrically belongs to either archaic *Homo sapiens* or early anatomically-modern *Homo sapiens*. The study examines and measures morphological features of EH-06 and then compares with published and unpublished data of the morphologies and measurements of frontal bones of both *Homo* erectus, archaic and anatomically-modern *Homo* sapiens throughout some of the most representative sites in Africa and Eurasia.

The results from this study will provide additional information on the position of EH-06 as archaic *Homo sapiens* versus anatomically modern *Homo sapiens*. It will also provide some insights about whether anatomically-modern *Homo sapiens* evolved from archaic *Homo sapiens* anagenetically or cladistically. This is, in particular, important, given the fact that in Bed VIB of Mumba rock shelter, few kilometres from where EH-06 was found, three isolated teeth of anatomically-modern *Homo* sapiens were recovered from excavation, dating to about 130 years BP (Mehlman 1989). Did EH-06 co-existed in time and space with anatomically-modern *homo sapiens* as evidenced in the Eyasi Basin?

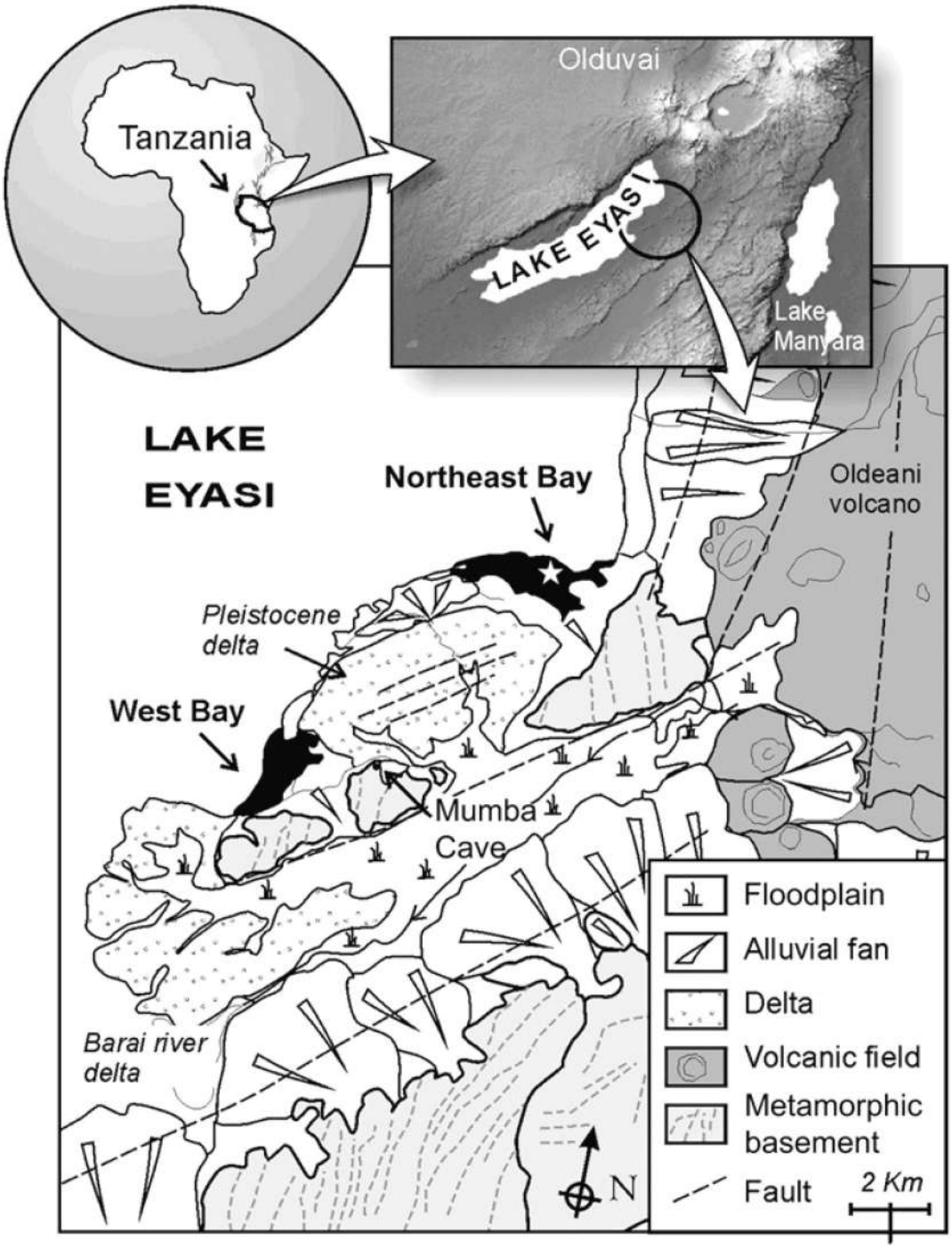


Figure 1: Location of Eyasi Basin. Location of EH-06 discovery is indicated by star (after Dominguez-Rodrigo et. al. 2008)

Figure 2: The hominid frontal bone (EH06) from superior (a), basilar (endocranial) (b), anterior (c), partial lateral (d), and lateral (e) views. (Dominguez-Rodrigo et. al. 2008)

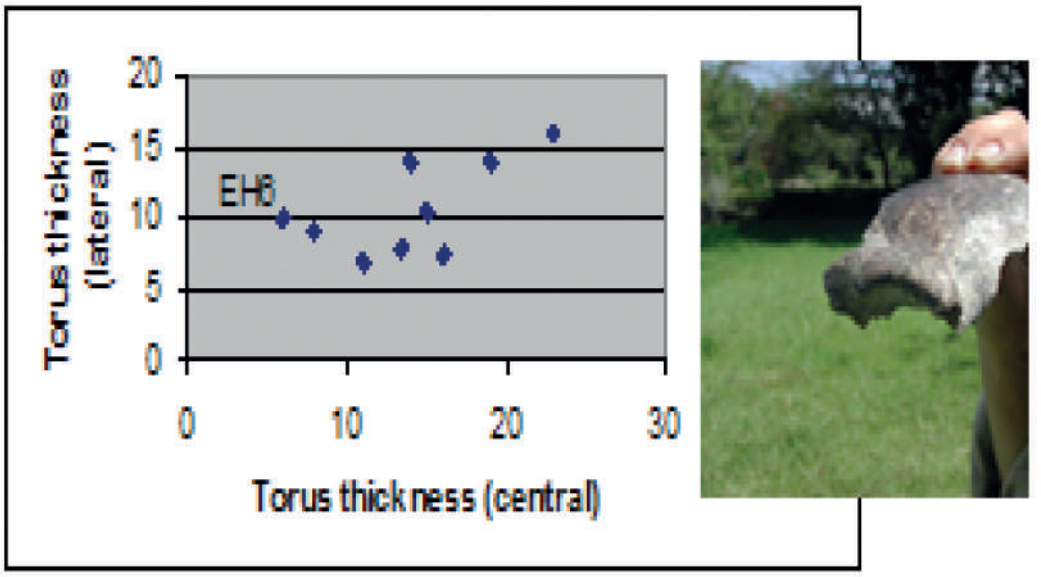
Morphological description of EH- 06

The fossil frontal bone (EH-06) shows excellent cortical preservation, on which no traces of polishing of the edges or abrasion are observed (Fig. 2). Approximately half of the frontal bone with the left supraorbital rim has been preserved. A very small portion of the lateral ridge of the sagittal sulcus (3 mm) can be documented on the endocraneal surface. No portion of the internal part of the groove is preserved. The forward projection of the midline brow ridge relative to the frontal squama creates a very flat and straight supratoral surface (25 mm), interrupted by a prominent lateral glabellar swelling. This is shown in a raised midline glabellar torus in the sagittal plane of the frontal bone. Behind glabella, there is a slight depression, but a well-defined postorbital sulcus was not developed.

The glabellar swelling extends approximately 16 mm to the medial side of the orbital rim. A supraorbital notch is present just below the lateral most extent of the glabellar swelling. The glabellar torus creates a robust superciliary arch, which thins abruptly before reaching the midsection of the orbital rim. This supratoral section is 6 mm1 at midorbit and thickens again towards the lateral aspect of the supraorbital trigone (10 mm). The temporal line is crested anteriorly and there is marked postorbital constriction. There is a very slightly protruding frontal boss. A portion of the coronal suture superior to pterion has been preserved. Endocranial surface preserves several fossae including meningeal vessel impressions (Domínguez –Rodrigo et al. 2008)

Materials and Methods

The morphology of the frontal bone and the supraorbital torus in particular are used to distinguish fossil hominin groups. Using a digital calliper, this study examined and measured five (5) morphological variables on EH-06 frontal bone. The morphological variables measured include: 1) supra orbital torus thickness (central and lateral), 2) minimum frontal breadth, 3) maximum frontal breadth, 4) biorbital chord, and 5) post orbital constriction index (calculated as: maximum frontal breadth x 100/bizygomatic breadth).



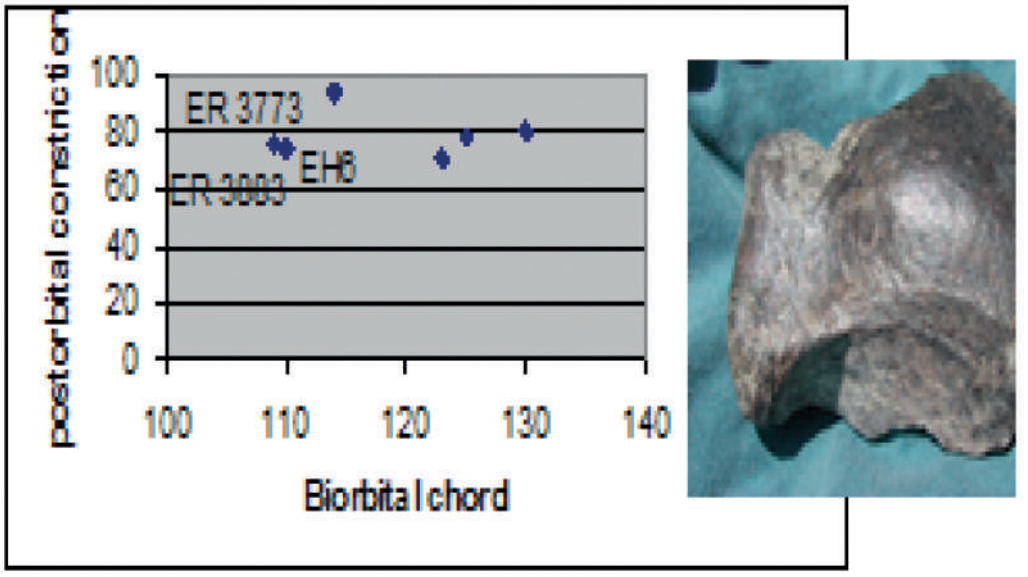


Figure 3.The collected data is then grouped with similar published data of eighteen (18) hominin remains from Africa, Asia and the Near East dating from early- to late Pleistocene.

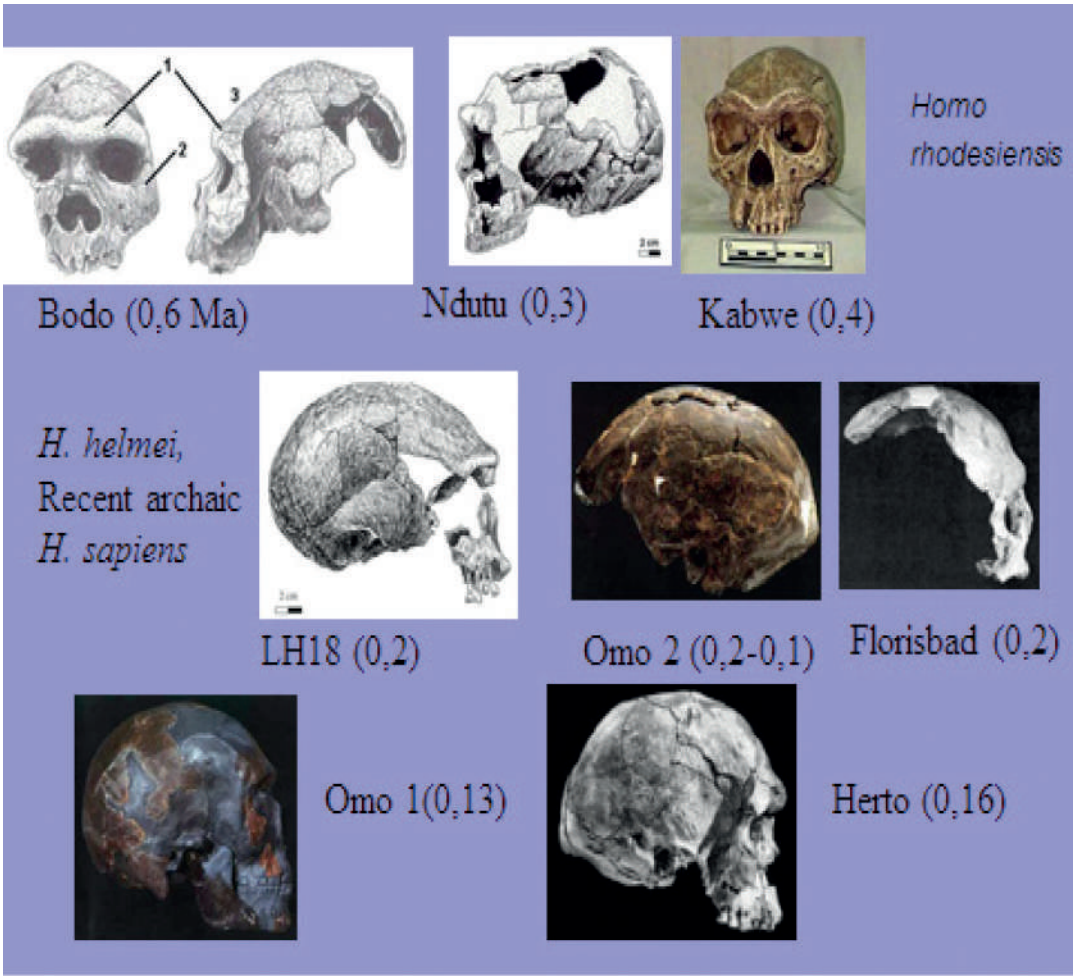


Figure 4. Some of the hominin remains from Africa, Eurasia, used in this study.

The principle component analysis (PCA) and cluster method analysis are performed to establish the position of EH-06 on the early-to late Pleistocene hominin frontal morphological continuum.

Results

The measured and published frontal morphological variables are presented in Table 1. However, in order to undertake the Principle Component Analysis PCA and cluster analysis the original data in Table 1 has to be standardized using the

Z method that uses the formula store (Item mean value/Standard deviation). The standardized data are presented in Table 2.

	Supraorbital Torus thickness (central)	Supraorbital Torus thickness (lateral)	Minimal frontal breadth	Maximal frontal breadth	Biorbital chord	Postorbital Constriction Index	
EH-06	6	10	88	102	112	83	our hominid
KNMER3733*	8	9	83	110	109	76,1	African 1,5 Ma
KNMER3883*	11	7	80	105	110	72,7	African 1,5 Ma
OH9*	19	14	88	-	123	71,5	African 1 Ma
D3444	10	11	68	100	98	69	Asian 1,5 Ma
D2280	11	9	75	105	105	71	Asian 1,5 Ma
D2282	11	6	66	87	96	69	Asian 1,5 Ma
D2700	8	6	67	85	90	75	Asian 1,5 Ma
NDUTU*	11	10,5	102	112	-	-	African middle pleistocene
KABWE*	23	16	98	118	125	78,4	African middle pleistocene
BODO	16	7,5	105	119	130	80,7	African middle pleistocene
LAETOLI18**	14	14	104	116	112	91	African middle pleistocene
OMO 2	13,5	8	108	120	114	94,7	
skhul5	9,5	10	99	125	122	82	Near East upper pleistocene
skhul9	12,5	11,5	96	122	124	77	Near East upper pleistocene
QAFZEH6	16,5	13,9	109	127	124	88	Near East upper pleistocene
asia1	15	13	102	116	114	89	asian middle pleistocene
asia2	13	13	106	120	90	88	asian middle pleistocene
asia3	14	10	103	114	113	90	asian middle pleistocene
asia4	19	14	88	108	123	71	asian middle pleistocene

Table 1:Results of the Pleistocene hominins from Africa and Asia with measured and published frontal bone morphological variables (Original dataset).

	Supraorbital Torus thickness (central)	Supraorbital Torus thickness (lateral)	Minimal frontal breadth	Maximal frontal breadth	Biorbital chord	Postorbital Constriction Index
EH-06	-1,677	-0,227	-0,261	-0,781	-0,026	0,38
KNMER3733*	-1,201	-0,567	-0,61	-0,095	-0,275	-0,451
KNMER3883*	-0,488	-1,245	-0,819	-0,524	-0,192	-0,861
OH9*	1,415	1,13	-0,261		0,887	-1,006
D3444	-0,725	0,112	-1,655	-0,953	-1,188	-1,307
D2280	-0,488	-0,567	-1,167	-0,524	-0,607	-1,066
D2282	-0,488	-1,585	-1,794	-2,069	-1,354	-1,307
D2700	1,903	-1,585	-1,724	-2,24	-1,852	-0,584
NDUTU*	-0,488	-0,058	0,714	0,077		
KABWE*	2,366	1,809	0,435	0,592	1,053	-0,174
BODO	0,702	-1,076	0,923	0,678	1,468	0,103
LAETOLI18**	0,226	1,13	0,854	0,42	-0,026	1,343
OMO 2	0,107	-0,906	1,132	0,763	0,14	1,789
skhul5	-0,844	-0,227	0,505	1,192	0,804	0,259
skhul9	-0,131	0,282	0,296	0,935	0,97	-0,343
QAFZEH6	0,82	1,096	1,202	1,364	0,97	0,982
asia1	0,464	0,791	0,714	0,42	0,14	1,103
asia2	-0,012	0,791	0,993	0,763	-1,852	0,982
asia3	0,226	-0,227	0,784	0,248	0,057	1,223
asia4	1,415	1,13	-0,261	-0,267	0,887	-1,066

Table 2:Standardized data by using a Principle Component Analysis

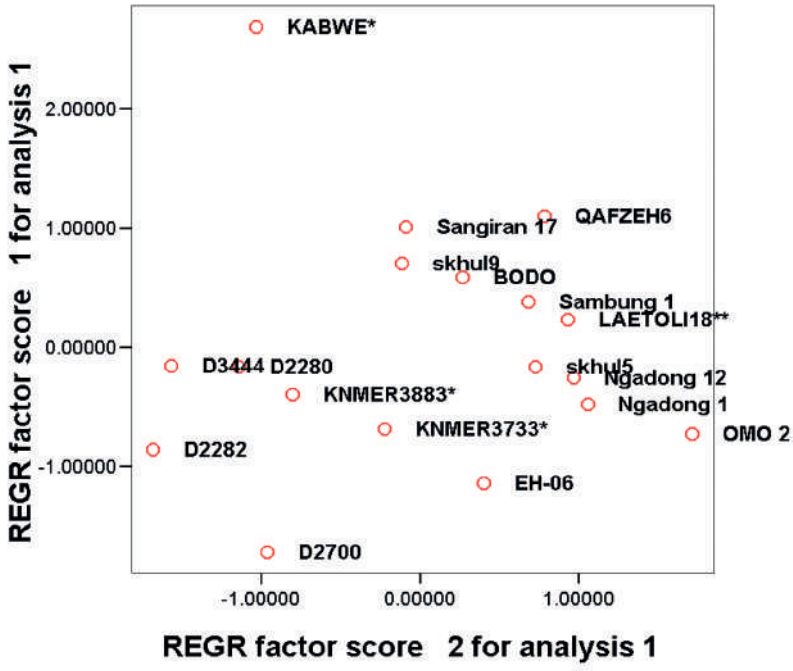


Figure 5. Graphic result of two main factors component analysis showing the association of hominid Eyasi with early hominids in Africa and the Middle East, showing a primitive architecture front.

A PCA test based on a two-factor solution, selected with eigenvalues higher than 1, indicated that, most of the variance (68%) is explained by Minimal Frontal Breadth y Maximal Frontal Breadth. The remaining variance (12,4%) is explained by a second factor comprising the other variables.

PCA was performed and the results are presented in Figure 2. The results show EH-06 grouping with African *Homo erectus* (such as KNMER3733, KNMER3883 from Kenya) and to a lesser degree with Asian *Homo erectus* (Ngadong 1 and 12), African archaic *Homo sapiens* (Omo 2) and Asian anatomically-modern *Homo sapiens* (Skhul5).

The cluster analysis (made by principal component analysis) also yielded a similar result, in which EH=6 clusters with African Homo erectus from the Lower Pleistocene and then the Asian specimens that show more primitive features (Figure 3). These latter are the Dmanisi early Homo specimens.

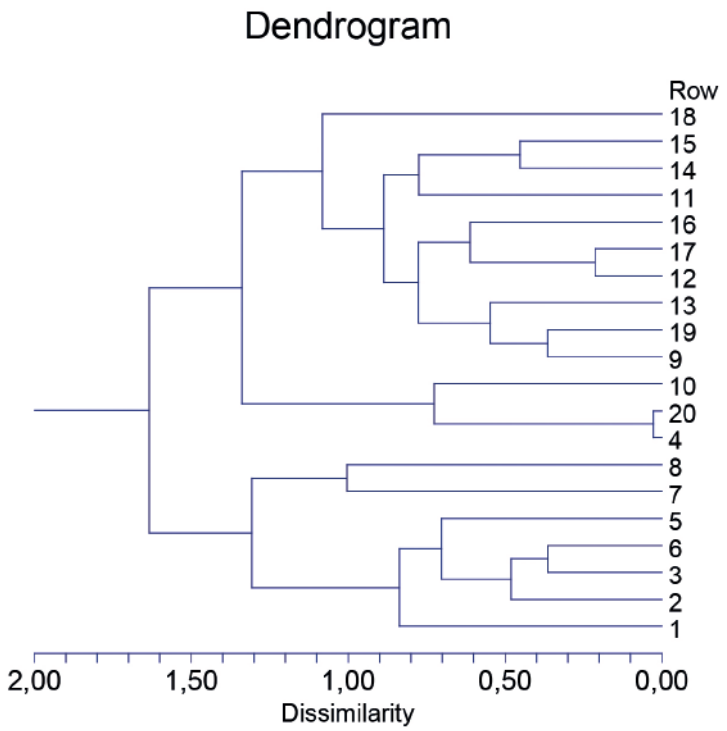


Figure 6. Cluster analysis with the same data showing a similar association of hominids to that obtained by principal component analysis. The numbers show hominins as listed in order in Table 1.

Discussion

Eyasi Hominin (EH06) exhibits a central supra-orbital torus thickness of 6.0. This is the thinnest of all the studied hominin fossils. Nonetheless, in this aspect, it can be grouped together with African and Asian *Homo erectus*, dating to about 1.5 Ma such as KNMER3733 and D2700 and Near East anatomically-modern *Homo sapiens* dating to late Pleistocene, about 120-90 ka such as Skhul5. These have a central supra-orbital torus of 8.0. The lateral supra-orbital torus for EH-06 is 10.0 same as Skhul5 and Asia3. Also, closely it groups with Asian 1.5 Ma *Homo erectus* (D2280) and middle Pleistocene African Ndutu skull, with 9.0 and 10.5 thicknesses, respectively.

In terms of post-orbital constriction index, EH-06 group closely with anatomically-modern *Homo sapiens* fossil remains such as Skhul5. On the basis of these morphological features, EH-06 exhibits features of Homo erectus and archaic *Homo sapiens*, but more moving towards frontal morphological features of anatomically-modern *Homo sapiens*.

Conclusion

On the basis of the morphological features, the Eyasi hominid morphology is closer to those of the Lower Pleistocene hominids and the earliest Middle Pleistocene, rather than modern forms documented on the same date in Eyasi. This suggests two options, the first is that there is greater morphological variability in early Homo sapiens and the second is that the timing may be wrong and the site advised re-dating with the new dating technology.

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