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## Comment on "The Brain of LB1, *Homo floresiensis*"

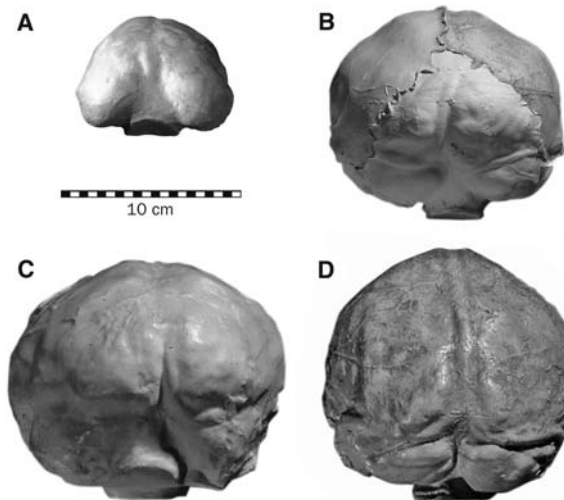
Falk *et al.* (1) presented new data on the 18,000-year-old type specimen LB1 of the dwarf hominin *Homo floresiensis* (2, 3) with regard to cranial capacity and its implications for human evolution. They revised the originally determined brain size of only 380 cm<sup>3</sup> (2) measured with mustard seeds) to 417 cm<sup>3</sup> [estimated by three-dimensional (3D) computed tomography] and rejected the hypothesis that LB1 was a microcephalic individual (Fig. 1). We disagree with this conclusion and have subsequently analyzed 19 microcephalic modern humans. The corresponding brain volume varies between 280 and 591 cm<sup>3</sup>, with a mean value of 404 cm<sup>3</sup>. Thus, the virtual cranial capacity estimate for *H. floresiensis* is well within the range of variation for microcephalic brain volumes, with the newly determined capacity of LB1 being quite close to the microcephalic mean value. In addition, similarities or phenocopies between LB1 and microcephalic skulls are evident with respect to the supraorbital torus (a ridge on the frontal bone above the eye socket), the postorbital constriction, and the protrusion of incisors.

Within our collection of microcephalic specimens, we focused on an endocast with a cranial capacity of 415 cm<sup>3</sup>, which is comparable to that of the *H. floresiensis* type specimen. We calculated the same six diagnostic indices indicated for LB1 [see table 1 in (1)] and found that the values for our specimen are nearly identical to those obtained for *H. floresiensis*, which are shown in parentheses: breadth/length = 0.85 (0.86); height/length = 0.68 (0.68); frontal breadth/length = 0.64 (0.65); (breadth minus frontal breadth)/length = 0.21 (0.21); (breadth minus frontal breadth)/height = 0.31 (0.31); and height/breadth = 0.80 (0.79)

Both skull and brain morphologies of microcephalics are extremely heterogeneous and grossly resemble the anatomy and proportions of *H. floresiensis* (Fig. 2). In microcephalic brains of similar or identical endocranial volume, we observed widely differing index measurements. For example, a 407-cm<sup>3</sup> specimen had a frontal breadth/length index of 0.55 and a height/breadth index of 0.74, compared with values of 0.64 and 0.8, respectively, for the 415-cm<sup>3</sup> microcephalic resembling *H. floresiensis*. Even greater deviations were seen in a pair

of endocasts with a volume of ~306 cm<sup>3</sup>, and the indices of one of them resemble those of *Paranthropus aethiopicus* (1). Furthermore, previous studies have noted that brain volume seen in primary microcephaly is comparable to that of early hominids (4, 5).

We also found great variability with regard to the overall microcephalic brain shape, with some specimens showing small frontal and temporal lobes relative to the parieto-occipital region and some displaying extremely wide temporal lobes (brachyencephaly). Thus, no typical diagnostic brain shape and convolution pattern was obvious. Therefore, we agree with Thorne [cited in (6)] and others (7) in



**Fig. 1.** Occipital comparison of size and brain morphology between (A) a microcephalic *H. sapiens*, (B) *H. erectus*, (C) *H. neanderthalensis*, and (D) a normal *H. sapiens*. The brains of microcephalics are as a rule entirely reduced in size, with only the cerebellum sometimes being disproportionately large.

questioning the value of a single microcephalic endocast (1) as the basis to exclude a microcephalic anatomy. Moreover, simple gyrification is believed to be typical for microcephaly. However, in nine brains we observed no simplified gyral patterns, implying that this feature is not pathognomonic for microcephaly (8, 9).

The most convoluted region of the *H. floresiensis* brain is in the most forward-projecting part of the frontal lobe (prefrontal cortex). This region, known as Brodmann's area 10, is expanded in modern humans and is involved in undertaking initiatives and planning future actions (10). Because this is believed to be a key component of higher cognition, it

has been suggested that the Flores hominids may well have been capable of creating the stone tools that were found near them. However, compared with other brain regions, area 10 is also relatively enlarged in seven of our microcephalic brain specimens. (Five of the seven are shown in Fig. 3.) Generally, the brain function and life expectancy of individuals with microcephaly vary depending on the underlying cause of the condition (11). We know from our records that a male individual with an intracranial volume of 485 cm<sup>3</sup> and a prominent area 10 was able to walk but could not speak even a few words or a short sentence. He showed profound mental retardation and, thus, could not plan or perform complex actions. The presence of an unusually prominent area 10 therefore does not necessarily imply advanced cognition. We also stress that brains of both adult microcephalics and healthy humans no longer occupy the entire cranial cavity (11). Therefore, deducing correct brain size/proportions from endocasts is widely inaccurate because brain-endocast relations have not been determined yet. Because Falk *et al.* evaluated only one microcephalic endocast (1), it is premature to exclude LB1 from any pathological anatomy. Analysis of other skulls from the Indonesian island of Flores will help address the correct taxonomy of the small-brained hominid.

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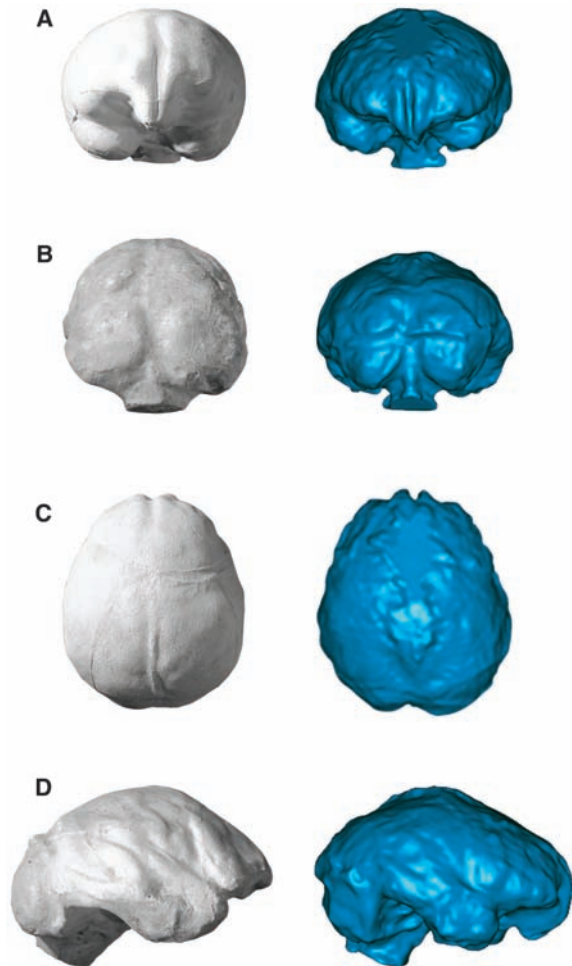
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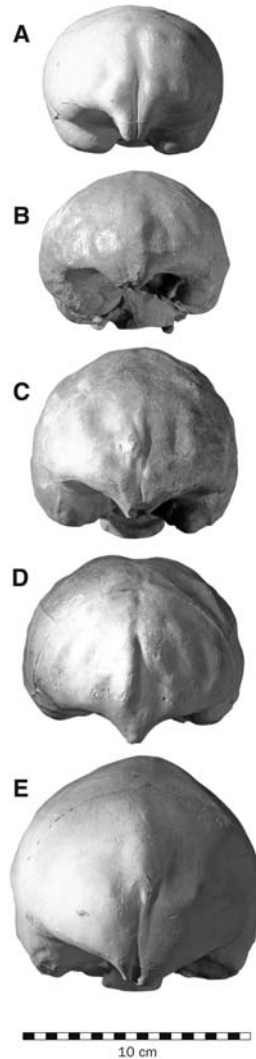
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**Fig. 2.** Comparison of modern microcephalic endocast (left) with the 3D reconstruction of the *H. floresiensis* endocast (right). Views: (A) frontal; (B) occipital; (C) vertical; (D) right lateral. Note the similarities in morphology, proportions, and shape between the modern microcephalic and the hominid endocast of LB1. [Blue images taken from Falk *et al.* (1)]



**Fig. 3.** Exemplary frontal views of the prominent Brodmann's area 10 (with or without depression) in five microcephalic individuals. Note the degree of morphological variability in microcephalics. All of the microcephaly patients were profoundly or severely mentally retarded.

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