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Internal cranial features of the Mojokerto child fossil (East Java, Indonesia)

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Abstract

The island of Java, Indonesia, has produced a remarkable number of fossil hominid remains. One of the earliest specimens was found in Perning and consists of an almost complete calvaria belonging to a juvenile individual, known as the Mojokerto child (Perning I). Using computed tomography, this study details its endocranial features. The specimen is still filled with sediment, but its inner surface is well preserved, and we were able to reconstruct its endocranial features electronically. The Mojokerto endocast is the only cerebral evidence available for such a young *Homo erectus* individual. We provide an analytical description, make comparisons with endocasts of other fossil hominids and modern humans, and discuss its individual age and taxonomic affinities. The ontogenetic pattern indicated by the Mojokerto child suggests that the growth and development of the *Homo erectus* brain was different from that of modern humans. The earliest stages of development, as characterized by this individual, correspond to important supero-inferior expansion, and relative rounding of the cerebrum. The following stages differ from that of modern humans by marked antero-posterior flattening of the brain and particularly antero-posterior development of the frontal lobes, resulting in the adult *H. erectus* morphology.

Keywords: Endocast; *Homo erectus*; Mojokerto; Java; Indonesia; Ontogenesis; Development; Growth; CT

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Introduction

The island of Java, in Indonesia, is a centre of extraordinary paleoanthropological interest. The first discoveries date back to 1891 when crews working for Eugène Dubois found fossils at Trinil that he attributed to *Pithecanthropus erectus* (Dubois, 1894). Since then numerous other field projects were undertaken throughout the island. Among the oldest specimens is the nearly complete calvaria of a young individual from Perning (von Koenigswald, 1936). The "Mojokerto child" could be as old as 1.81 Ma (Swisher et al., 1994) and, together with the Dmanisi fossil record (Gabounia and Vekua, 1995; Gabounia et al., 2002; Vekua et al., 2002; Antón, 2003), would represent some of the earliest evidence of hominid dispersal outside of Africa.

Perning I consists of an almost complete immature calvaria, including parts of the orbital plates and both petrous temporals; missing elements include the right portion of the frontal torus, the inferior region of the parietals, the squamous part of both temporals, and the lateral and the inferior portions of the occipital bone (for an exhaustive description of the individual, see Antón, 1997).

There are many discussions concerning the stratigraphical position and absolute age of Perning I (*e.g.* Hyodo et al., 1993, 2002; Swisher et al., 1994; Huffman and Zaim, 2003). On the whole, investigation of original archival records, and the evidence from subsequent fieldwork, support the conclusion that the calvaria was found *in situ* in the Upper Pucangan Formation (Duyfjes, 1936; Huffman, 2001). With special reference to this aspect, de Terra (1938: 4), who also compared directly the matrix in the calvaria and the sediment from the site, stated that "*in spite of the shallowness of its position there is nothing to cast a shadow of doubt on the stratigraphic position of the skull*". By absolute dating pumice pebbles and hornblende sand coming from the same site but from the underlying horizon (Huffman and Zaim, 2003), Swisher et al. (1994) have proposed an age for the Mojokerto child of 1.81 $\pm$ 0.04 Ma. However, there is no evidence that the hominid specimen and the dated matrix are contemporary. Even if the stratigraphical position of the fossil is certain, the volcanic sediment could have been reworked during the erosion of the volcano, and could therefore be older. Nonetheless, the reversed magnetic polarity of the volcanic sediments shows that this layer certainly precedes the Brunhes/Matuyama boundary (Sémah, 1986). Therefore, the absolute age of the Mojokerto child must be between 0.78 Ma and $\sim$1.81 Ma.

A long time after its discovery, the taxonomic attribution and developmental age of the Mojokerto child are still in debate. Major difficulties come from the incomplete and immature nature of the specimen, and the lack of adequate comparative material. Historically, this individual was identified as *Homo soloensis* (Dubois, 1936), *Australopithecus* (Campbell, 1973), *Pithecanthropus modjokertensis* (Jacob, 1975; Sartono, 1975), *H. erectus* (*e.g.* Risçutia, 1975; Storm, 1994; Antón, 1997), and even *H. sapiens* (Weinert, 1938). The age at death estimates fluctuate between 1 year to over 8 years (Dubois, 1936; Weinert, 1938; von Koenigswald, 1940; Risçutia, 1975; Antón, 1997; Coqueugniot et al., 2001, 2004). Recent studies have concluded that the Mojokerto child is best considered as *H. erectus* based on cranial features shared with adult specimens belonging to this species (Storm, 1994; Antón, 1997).

The matrix filling precludes one from viewing the endocranial cavity and the internal features of the Mojokerto child (Fig. 1). Computed tomography (CT) enabled us to study the state of preservation and the degree of deformation of the calvaria and its endocast (reconstructed electronically in this study), as well as details of suture closure and internal cranial features (Fig. 2), including the bony labyrinth and other osseous structures. We present a detailed analytical description of the endocranial cast of Perning I, and make comparisons with endocasts of other fossil hominids and modern humans. Furthermore, as the growth and developmental patterns in *H. erectus* are still poorly documented (see Thompson and Nelson, 2000; Dean et al., 2001), we contribute to this key topic by assessing brain development during ontogeny in an early representative of this fossil taxon.