The endocranial cast of a 10 ka intentionally deformed human cranium from China

Yin Qiyu[1,2], Li Qiang[1,2,3], Ma Ming[1], Zhang Wei[1], Ni Xijun[1,2,3]*

[1] *Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xi Zhi Men Wai Street, Beijing, 100044, China*

[2] *University of Chinese Academy of Sciences, Beijing 100049, China*

[3] *CAS Center for Excellence in Life and Paleoenvironment, Beijing, 100044, China*

*__Corresponding author__: nixijun@ivpp.ac.cn

Abstract

This contribution contains the 3D model of an endocranial cast analyzed in "A 10 ka intentionally deformed human skull from Northeast Asia". There are many studies on the morphological characteristics of intentional cranial deformation (ICD), but few related 3D models were published. Here, we present the surface model of an intentionally deformed 10 ka human cranium for further research on ICD practice. The 3D model of the endocranial cast of this ICD cranium was discovered near Harbin City, Province Heilongjiang, Northeast China. The fossil preserved only the frontal, parietal, and occipital bones. To complete the endocast model of the specimen, we printed a 3D model and used modeling clay to reconstruct the missing part based on the general form of the modern human endocast morphology.

Keywords: endocranial cast, intentional cranial deformation, Northeast China

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INTRODUCTION

An endocranial cast is a cast of the cranial cavity formed by the brain impression. The endocranial cast provides a great deal of morphological information, including endocranial size, shape, and structure (Zollikofer & De León, 2013). The craniofacial complex is developmentally plastic, thus endocranial structures are easily deformed when subjected to constant external pressure during growth (Dean, 1996). Also, the preserved endocranial vascular traces are critical for investigating the role of the vascular system in the human brain (Beaudet et al., 2019). Many techniques can be used to reconstruct an endocranial cast from a fossil cranium, including surface scan, CT scan, and various 3D modeling methods. One way for endocast restoration from an incomplete cranium is to print a 3D model and use the modeling clay to fill the missing parts. Another method is to use digital reconstruction methods, such as landmark-based retrodeformation, to reverse the morphological changes or reconstruct the missing areas (Neubauer et al., 2018). The present 3D Dataset contains a structure-light surface model (see Fig. 1 and Table 1) of a reconstructed endocranial cast of an intentionally deformed cranium found from the Dadingzi Hill underwater sand mine near the Songhuajiang River. Calibrated accelerator mass spectrometry radiocarbon age of the cranium is 11,095-10,745 BP. Intentional cranial deformation is a type of body modification that leads to the elongation of the cranium and the flattening of certain areas (Yin et al., 2020). The practice of intentional cranial deformation can affect craniofacial shape dramatically. In the meantime, ICD practice has a significant effect on venous sinus and middle meningeal vessel patterns, such as the direction of the middle meningeal vessel impressions (Dean, 1995).

Inv nr.	Description
IVPP-PA1616_M3#976	Original endocranial cast model (with texture) of IVPP-PA1616.
IVPP-PA1616_M3#972	Restored complete 3D model of the endocranium of IVPP-PA1616.

Table 1. Endocranial models of IVPP-PA1616 (*Homo sapiens*; collection:IVPP, Beijing, China)

A detailed morphological description of the cranium has been reported in Yin et al. (2022).

METHODS

The physical model of the endocast and the fossil specimen (IVPP PA1616) are curated at the Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences. First, the fossil specimen was scanned using the Artec Space Spider high-resolution 3D surface scanner with a resolution of 0.1 mm at the Key Laboratory of Vertebrate Evolution and Human Origins, Chinese Academy of Sciences. Then, we used Artec Studio 14 Professional to segment the inner surface of the cranium. The 3D model of the incomplete endocranial surface was printed using a 3D printer housed in the same institute. Subtle features on the endocranial surface, such as blood vessels and venous sinuses, were preserved on the printed model. The restoration of the endocast involve only the base of the endocast, as the calvaria was complete. The tabular deformation only involves the morphological change of frontal, parietal and occipital bones, there is no effect on temporal bone and sphenoid bone. Therefore, the printed endocast of the specimen can be reconstructed based on the general form of the modern human

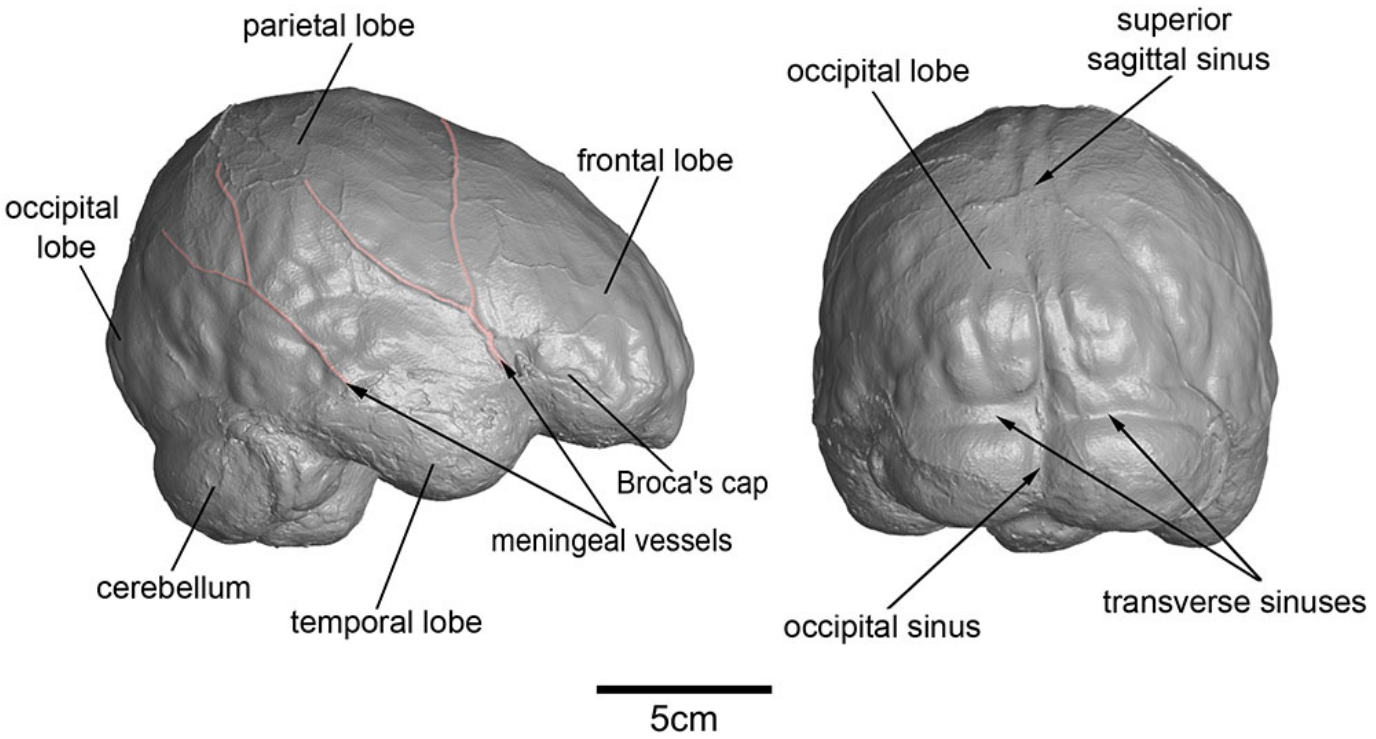

Figure 1. Different structures of the reconstructed endocast. Left: right lateral view. Right: posterior view.

endocranial cast morphology. The missing parts of the printed model were restored using modeling clay. After filling the missing parts, the model was scanned again using the Artec Space Spider 3D surface scanner. The 3D model surface is provided in .ply format.

There are three depressions at the base of the cranial cavity, known as the anterior, middle and posterior cranial fossae. As the temporal and sphenoid bones were not preserved, all the fossae and the cerebellar lobes were missing and reconstructed. As a whole, the endocast of PA1616 has a less rounded appearance than a regular modern human endocast (see Fig. 2). The elongation and sloping of the endocast model show typical features of intentional cranial deformation. The maximum endocast width is 133.23 mm, the maximum endocast length is 168.90 mm, and the maximum endocast height (the vertical distance between the highest point of the parietal lobe and the ventral limit of the cerebellum) is 130.24 mm. An endocranial volume of 1,390 ml was estimated, falling in the range of modern human. The frontal region of the endocast is flattened, probably formed by the constant pressure on the frontal bone during growth. There is a well-developed frontal crest on the endocranial surface. The endocast widens posteriorly from the frontal lobe. The widest point of the endocast is at the lateral border of the parietal lobe. The lower parietal areas display a marked lateral expansion. The overall shape of the endocast is asymmetrical, with the left side of the parietal lobe being more laterally expanded than the right side. Like the frontal lobe, the occipital lobe is also anteroposteriorly flattened. Flattening of frontal and occipital is the typical characteristic of tabular deformation (Tubbs et al., 2006). Compared with a regular human endocast, the occipital lobe has a weak posterior projection. The left part of the occipital lobe is larger and extends more posteriorly than the right part. There are several well-preserved traces of the vascular system along the sides of the endocast. Compared with the posterior branches, the anterior branches of the middle meningeal vessels are deeper and thicker. More branches of the meningeal vessels overlie the middle and posterior regions of the endocast. The sagittal sinus on the endocranial surface drains to the right transverse sinus.

DISCUSSION

The ICD practice alters not only the shape of the cranium, but also the endocranial morphology, including both the shape and the direction of the vessels and the location of the venous sinuses. The surface model of the endocast of PA1616 provides more data for further research on ICD practice.

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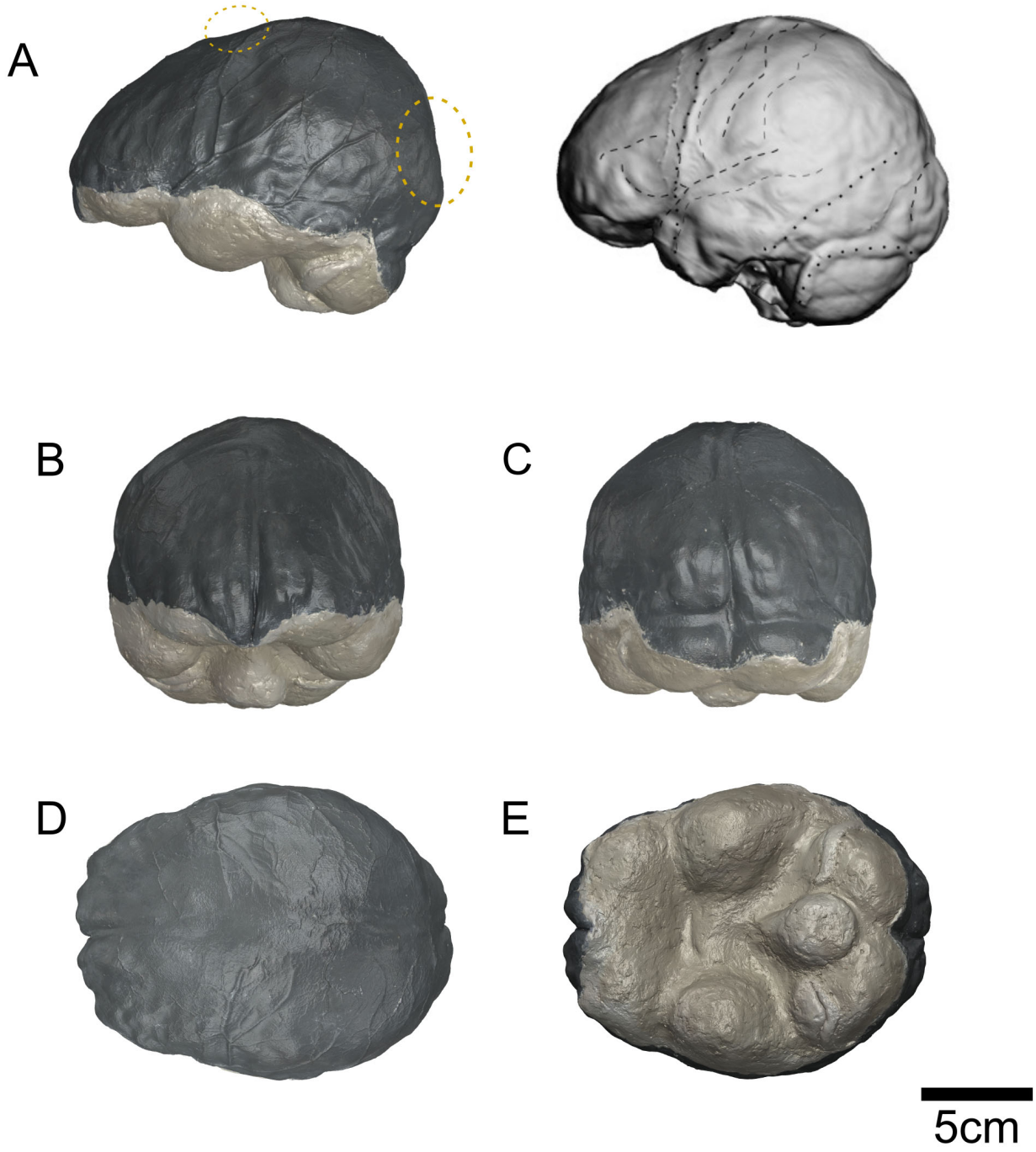

Figure 2. 3D model of the reconstructed endocast of specimen PA1616. A: Left: left lateral view of the endocast of PA1616, yellow dashed lines show the flat areas on frontal and occipital lobes. Right: left lateral view of the endocast of a modern human (reproduced with the permission of Zollikofer & De León, 2013, Copyright © 2013 Wiley Periodicals, Inc.), dashed lines indicate endocranial surface structures; B: anterior view; C: posterior view; D: dorsal view; E: ventral view.

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