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The Difference in Cranium Morphological Characteristics of *Homo sapiens*, *Pithecanthropus erectus*, and *Pithecanthropus soloensis*

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Abstract. Modern human (*Homo sapiens*) are living things that have evolved through the evolutionary process from a kind of Primates. The history of human evolution is studied through discovery of fossilized body parts in layers of the earth. Early human *Pithecanthropus* is the most type commonly found in Indonesia, such as *Pithecanthropus erectus* and *Pithecanthropus soloensis*. Early human have different physical characters from modern human. Morphological characters are commonly used for identification of early human fossils. Cranium plays an important role in fossil identification because it has different variations between species as a result of evolution. This study aims to determine the differences in cranium morphological characters from *H. sapiens*, *P. erectus*, and *P. soloensis*. The research was conducted by observing the morphological characters of cranium. Data analysis with descriptive qualitative. The difference in cranium morphological characteristics of *H. sapiens*, *P. erectus*, and *P. soloensis* are the shape of cranium in verticalis norm, parietal tuber, and supraorbital torus. Cranium morphological characters is simply and reliable to identify the types of hominid species.

Keywords: *Homo sapiens*; *Pithecanthropus erectus*; *Pithecanthropus soloensis*; cranium; morphology.

Running Title : The Difference in Cranium of *Homo sapiens, Pithecanthropus erectus,* and *Pithecanthropus soloensis*

INTRODUCTION

The process of biological evolution has been going on for a very long time. Starting from a simple form and then developing into complex organisms. Many old life forms have disappeared, but another have survived and still alive today. Living things today are the result of branching evolution of their ancestors. Human differ from other Primates in their significantly lengthened growth period (Coqueugniot, Hublin, Veillon, Houet, & Jacob, 2004). Human are classified in the class Mammalia and Primates tribes. The Primates tribe includes all types of monkeys and their countrymen. Primates is divided into two sub-tribes, namely Prosimil and Anthropoid. The Anthropoid sub-tribe is specifically divided into 3 infra-tribes, namely Ceboid, Cercopithecoid and Hominoid. Hominoids classified as one great ape with human. Hominoids were then further divided into two families, namely Pongidae and Hominidae. Hominidae also known as hominid classified into ancient human, such as *Pithecanthropus* and *Homoneanderthal* with modern human, *Homo sapiens*. *H. sapiens* are modern human who have developed and have many variations in the form of races (Koentjaraningrat, 1998). The evolutionary change could be ascribed in virtually its totality to slow generation-by-generation change in population gene pools, under the constant supervision of natural selection. The resulting paleoanthropological perspective was reinforced by the undeniable fact that *H. sapiens* is the only hominid extant today, which somehow made it seem natural that there should be only one hominid on Earth at any one time (Tattersall & Schwartz, 2009).

The process of evolution and human origins is studied specifically in the sub-science of biological anthropology, namely paleoanthropology. The history of human evolution is studied through discovery of fossilized body parts in layers of the earth (Koentjaraningrat, 1998). Research on human existence in Indonesia has been started since Eugene Dubois found fossils of the skull roof and thighbone of *Pithecantropus erectus* (Homo *erectus erectus*) at Trinil in 1891. Based on paleoanthropological evidence, the human population that first inhabited the Indonesian region was *P. erectus*. This species is thought to have evolved into a progressive type, namely *Pithecanthropus (Homo erectus) soloensis* or Solo Man, but later went extinct at 40,000 BP. The human population that is considered anatomically modern, the earliest to enter the Indo-Malaysian archipelago is *Homo (sapiens) wajakensis* around 50,000 BP which was found in Wajak (Tulung Agung) (Noerwidi, 2003; Pope & Cronin, 1984).

Early human *Pithecanthropus* is the most type commonly found in Indonesia. Human is one of the successful organisms in the Pleistocene and Holocene epochs. As a polytypic and polymorphic species, human shows a considerably wide variation. In Indonesia, which comprises thousands of islands with different environments and has experienced a remarkable geological history by repetitively acting as a landbridge between Asia on one hand with the Pacific and Australia. On the other, human variation is not surprisingly, wideranging. Variation among human is observed between age groups in a family, local populations, and races. Differences are noted between modern human and ancient/early human. The variation in time is clearly noticeable if follow the evolution of human since three million years ago. Variation is the theme of nature. Mutation is the primary source of variation. Sexual reproduction with segregation and recombination increases the number of possible genotypes. Different and changing habitats, interacting with the genotypes, create multivarious phenotypes (Jacob, 1974).

Early human have different physical characters from modern human. In Indonesia, early human had been present for two million years. His types belong to the genus *Pithecanthropus* which differs from modern human, *H. sapiens,* especially regarding the brain. On the cranial base, also finded traits that distinguish *Pithecanthropus* from *Homo* (Jacob, 1974). Morphological characters are commonly used for identification of early human fossils. Although an impressive number of contrasts exists between morphology of the early human and modern human. The differences between the earliest hominids and the late Miocene ancestors of the living early humans are likely to have been more subtle. Some of the features that distinguish modern human and early human, such as those linked to upright posture and bipedalism, can be traced far into human prehistory. Others, such as the relatively diminutive jaws and chewing teeth of modern human, were acquired more recently and thus cannot be used to discriminate between early hominid and ape ancestors (Wood & Richmond, 2000).

One important goal of biological morphology analysis is the physical characteristics comparison of species. The hominid morphology and treat each trait as the product of independent evolutionary mechanisms. Morphology is best described the inter-correlated nature of form. Recent comparatice morphology analysis of cranium in hominid have shown that a large of variability in shape parameters (Martinková & Janiga, 1999). Cranium plays an important role in fossil identification because it has different variations between species as a result of evolution. Cranium was the strongest part of hominid's skull, so was able to survive and not be damaged. Cranium morphology studies are important to know differences in the characteristics of hominids. This study aims to determine the differences in cranium morphological characters from *H. sapiens, P. erectus,* and *P. soloensis*.

MATERIALS AND METHODS

Study area

This research was conducted on 6 May 2019 at the Laboratory of Bioanthropology and Paleoanthropology, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia. The materials used were cranium fossil of *P. erectus, P. soloensis*, and *H. sapiens*.

Procedures

This research was conducted by observing the cranium fossils morphology of *P. erectus*, *P. soloensis*, and *H. sapiens* from the vertical side. Morphological characters were recorded and photos were taken to analyze the morphological differences.

Data analysis

Data analysis was carried out with descriptive qualitative methods to describe the differences in morphological characters of the cranium from 3 types of samples, namely *P. erectus*, *P. soloensis,* and *H. sapiens*.

RESULTS AND DISCUSSION

There has been continuous debate about the evolution and functional significance of features form in the cranium skeleton from living and fossil. The growth and development of bone structures is regulated by both intrinsic biological (e.g., genes, hormones) and mechanobiological (e.g., stress and strain magnitudes, strain rates) signals. Since adult bone is already largely adapted to external mechanical stimuli, one approach to understanding the evolution and phenotypic variation of features of form in the hominid cranium complex is to examine the relationship between the ontogenetic history of masticatory loadings and facial bone adaptation (Kupczik et al., 2009). The difference in the shape of cranium is an adaptive zone, especially in light of the probability that the full suite of characters associated with a zone is likely to have evolved in a mosaic fashion rather than appearing full blown at the base of the genus (Anton, 2012). The facial skeleton tends to be more variable than the neurocranium or the skull base and may be expected to exhibit high levels of within-species variation (Rightmire, Margvelashvili, & Lordkipanidze, 2018).

Increase in average cranial size over time was a theme common to multiple hominid clades over the middle and late Pleistocene. What it was that propelled such independent increase is unknown, and something that will have to be understood if ever to develop a full account of the human cognition evolution. However, it is notable that in only one hominid lineage have incontrovertible evidence before the end of Pleistocene, this trend had resulted in a creature with symbolic cognition (Tattersall & Schwartz, 2009). Early *Homo* had cognitive skills comparable to those of modern human, and it also implies that complex spoken language emerged relatively late in the course of human evolution (Coqueugniot et al., 2004).

Several morphological differences distinguish fossil members of the genus *Homo* including reduction in tooth and jaw size, reorganization of craniofacial morphology, and perhaps changes in body shape and size. And these physical differences have been taken to suggest underlying adaptive shifts at the origin of *Homo*, most or all have energetic and life history implications. Thus, the adaptive zone of *Homo* has been variously defined, implicitly or explicitly, relate either to cranial expansion and masticatory diminution and/or to increased locomotor efficiency and ranging relative to other hominid. Their criteria for distinguishing species of *Homo* was based on finding six classes of characteristics that were more similar to the condition in *H. sapiens*. The first criteria is monophyly. The last is an extended period of growth and development. The remaining four criteria are more explicitly related to the adaptive zone; three to reconstructions of body mass, shape, and proportions and one to jaw and tooth proportions as scaled to body-size-adjusted brain size. That aside, judging inclusion in a genus based on the association with its most derived member would seem to preclude the possibility of mosaic evolution in its earlier members (Anton, 2012).

Figure 1. Cranium in verticalis norm: a) *P. erectus*; b) *P. soloensis*; and c) *H. sapiens*

Based on the origin and evolution of *Homo*, *P. erectus* is now considered to take the first major anatomical and behavioral steps in the direction of a modern human body plan (Anton, 2003; Anton, Spoor, Fellmann, & Swisher, 2007; Walker & Leakey, 1993). Although the species was not identical to *H. sapiens* in size or shape, *P. erectus* bodies and brains were larger and their teeth and especially jaws were somewhat diminished in size, on average, compared with those of earlier members of *Homo* (Anton, 2008). However, their brains smaller than in later *Homo*. Although absolutes of size do not differ, some proportions do, and so individuals of *P. erectus* are relatively easy to differentiate from all other early *Homo* on the basis of craniodental remains. *P. erectus* also differs from other early *Homo* and modern human in other aspects of the cranium. The occipital squama is relatively short, and the petrous temporal is more sagittally oriented and angled relative to the tympanic portion (i.e., petrotympanic angle reduced; although the base of earlier *Homo* is not well known). The glenoid fossa is relatively broader anteroposteriorly (compared with mediolaterally) than in other early *Homo*. The face is described as more similar in proportions to modern human with other early *Homo*. Several characters scale with cranial capacity including cranial vault shape, smaller crania are more globular (Anton, 2012).

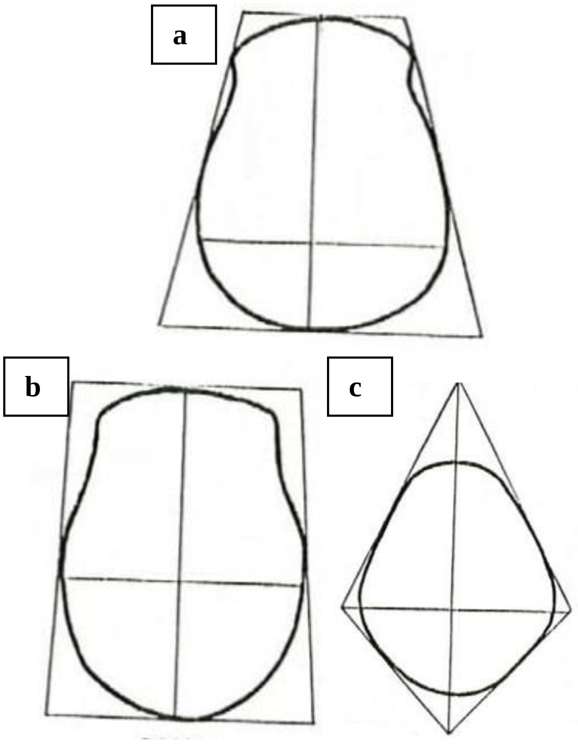
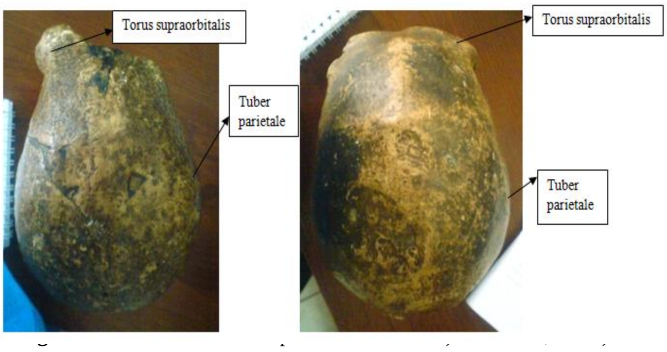


Figure 2. The shape of cranium in verticalis norm: a) *P. erectus*; b) *P. soloensis*; and c) *H. sapiens*

Morphological observations were made on the cranium of three hominid species, namely *P. erectus*, *P. soloensis*, and *H. sapiens*. Judging from the vertical side, there were differences in the morphology of cranium, namely the shape of cranium in verticalis norm (Figure 1). The verticalis norm is skull when seen from the upper part, above the outline presented varies greatly in different skulls, and it has an oval shape, in some it is more or less oval, in others more nearly circular but there are some racial and individual peculiarities (Durband, 2009). The surface is traversed by three sutures, (1) the coronal sutures, nearly transverse is direction, between the frontal and parietals; (2) the sagittal sutures, medially placed, between the parietal bones, and deeply serrated in its anterior two-thirds; and (3) the upper part of the lambdoidal suture, between the parietals and the occipital. The point of junction of the sagittal and coronal suture is named the bregma, that of the sagittal and lambdoid sutures, the lambda; they indicate respectively the positions of the anterior and posterior fontanelles in the fetal skull. On either side of the sagittal suture are the parietal eminence and parietal foramen that is frequently absent on one or both sides. The skull is often somewhat flattened in the neighborhood of the parietal foramina, and the term obelion is applied to that point of the sagittal suture which is on a level with the foramina. In front is the glabella, and on its lateral aspects are the superciliary arches, and above these the frontal eminences. Immediately above the glabella may be seen the remains of the frontal suture; in a small percentage of skulls this suture persists and extends along the middle line to the bregma. Passing backward and upward from the zygomatic processes of the frontal bone are the temporal lines, which mark the upper limits of the temporal fossæ. The zygomatic arches may or may not be seen projecting beyond the anterior portions of these lines (Bruner, 2018).

Examining the skull in verticalis norm, following shapes of skull can be distinguished: Dolichocephalic skull has an oval shape of the skull. Brachycephalic skull, it means a spheroid shape of the skull. Mesocephalic skull is an intermediate shape between the previous two forms (Bruner, 2018). The shape of cranium in the verticalis norm can be classified into three types (Figure 2). *P. erectus* has a spheroid shape which is included in the brachycephalic skull type, *P. soloensis* has a birsoid form which is included in the mesocephalic skull type, and *H. sapiens* has a rhomboid shape which is included in the dolichocephalic skull type.



soloensis

The parietale tuber in *P. erectus* are very pronounced and *P. soloensis* has well-defined parietal tubers. on the other hand, *H. sapiens* have a faint parietal tuber. The supraorbital torus is a protrusion above the eye. *P. erectus* and *P. soloensis* have a supraorbital torus, whereas *H. sapiens* does not have a supraorbital torus, but an arcus superciliaris. The supraorbital torus of *P. erectus* was more prominent than *P. soloensis* (Figure 3). Parietal tuber is prominent portion of the parietal bone, a little above the centre of its external surface, usually corresponding to the point of maximum width of the head which indicates the point where ossification commenced. *H. sapiens* often lacked a parietal foramen. The selective value of *P. erectus* and *P. soloensis* to maintaining a parietal eye for temperature regulation and modulating melatonin production, and may have been diminished in *H. sapiens*. The latter scenario is consistent with the lack of cyclic bone deposition and paucity of growth marks (Bruner, 2018; Huttenlocker & Botha-brink, 2014).

Supraorbital torus is part of the facial portion and typically further subdivided. All members of the genus *Homo* possess a projecting supraorbital torus with the exception of modern *H. sapiens*. Specifically this is referring to aprojecting browridge that is at minimum continuous over each orbit and has some vertical thickness. Such a structure is present in all archaic hominids and takes different forms over the orbits (arched vs straight), may or may not be interrupted by a swelling or depression at glabella, and varies in thickness supero-inferiorly. In contrast, modern human browridge development varies by population and, if present, is usually characterized mainly by pronounced supraciliary arches. If a lateral supraorbital arch is present, it is always interrupted by a supraorbital sulcus, thus precluding *H. sapiens* from having a proper supraorbital torus. Instead, the entire supraorbital region in modern human is occasionally referred to as the superciliary arch, not to be confused with the more medially situated supraciliary swelling defined above (Athreya, 2012; Hylander, Picq, & Johnson, 1991).

Modern human are characterized by a more vertical forehead or frontal squama and more retrognathic faces overall, which then eliminates the supratoral sulcus. Internally, the inferior portion of the frontal bone is occasionally characterized by a frontal sinus although its presence and form are highly variable in fossil and modern human. While the presence of a frontal sinus is often coincident with a prominent supraorbital torus, several studies have shown that sinus growth is not a driver of supraorbital morphology. Rather, as will be shown below, both appear to be a consequence of differential patterns of growth between the internal and external of the frontal bone (Athreya, 2012; Tseveendorj, Gunchinsuren, Gelegdorj, Yi, & Lee, 2016).

Previous research on frontal bone morphology can be grouped into two broad categories. Both share a focus mainly (but not exclusively) on the supraorbital region.

One group of structural/functional studies provides information on potential ontogenetic/behavioral sources of variation by exploring the relationship between craniofacial structure and function in an attempt to explain sources of variation in torus development among extant primates, including modern human. The second group of studies examines the geographical and temporal patterns of variation in frontal morphology to make inferences about phylogenetic relationships among fossil hominid populations in the Pleistocene. These two bodies of study are interdependent, because by understanding the possible developmental or behavioral sources of variation, it can then better evaluate the significance of geographic and temporal patterns of variation in this bone within the genus *Homo* (Athreya, 2012).

CONCLUSIONS

The difference in cranium morphological characteristics of *H. sapiens*, *P. erectus*, and *P. soloensis* are the shape of cranium in verticalis norm, parietal tuber, and supraorbital torus. Cranium morphological characters is simply and reliable to identify the types of hominid species.

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