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Morphology of early hominid hand in context of tool making

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This article will focus on morphology of hand early hominids. We already have not many hands fossils, but this evidences can help us to interpret early hominid`s potential of tools making. We will talk about Australopithecus afarensis, Australopithecus africanus, Australopithecus sediba, Paranthropus Robustus and Homo Habilis.

Keywords: archaeology, paleoanthropology, Australopithecus, Paranthropus, Early hominids, Evolution

Introduction

Early hominid research in Africa began in earnest in the second part of the 20th century, decades after the discovery of the Taung Child by Raymond Dart in 1924. After Dart's momentous discovery finally gained widespread acceptance, scientists at last came to understand that human ancestry began in Africa rather than the Far East as was previously believed. Unfortunately, there are very few carpal bones dating to this formative period of paleoanthropological research. Real interest in the development and implications of hominid hand morphology emerged only after the discovery of stone stools at Lomekwi 3 by Sonia Harmand in the 2010s. The discovery of 3-million-year-old tools fundamentally altered our understanding of the timeline of human cultural evolution. In addition to raising a number of pressing questions about the origins and definition of the genus Homo, Lomekwi 3 also radically reworked our understanding of the kinds of hand morphologies required for the production of stone tools. This brings us to the central question of this paper, namely, «which morphological features in early hominid hands are potentially indicative of tool making?»

When we are talking about Lomekwi its very important to understand that the stone tools found at the site have not yet been associated with any paleoanthropological remains. Nonetheless, the 3.3-million-year-old date of the

Lomekwi tools calls into question whether or not tool making can be said to be a trait unique to the genus Homo. We will see that by interpreting the carpal bones of the various early hominids present 3.3. million years ago, we are forced not only to abandon outmoded assumptions about uniquely Homo traits, but to also reconsider the cognitive and mechanical capabilities of previously underestimated early hominid groups. Our goal is to determine which groups of early hominids may have been capable of producing the Oldowan and Lomekwi toolkits based on functional morphology alone.

Because we don't find hominid remains holding tools, we need to make educated guesses about who made them. We can look at hand morphology, and its development, to attribute early tools to the particular hominids who may have made them.

This article will focus solely on the African context, which remains the only continent bearing evidence of early hominid presence prior to 2 million years before present. To evaluate the role of hand morphology in enabling the production of stone tools, we will further restrict our investigation to the chronological limits established from 3.67-1.75 million years ago, a period corresponding to both the earliest known tools as well as a myriad of changes in hominid hand morphology.

Australopithecus Afarensis

The first discovery of fossil remains belonging to Australopithecus Afarensis was made in Laetoli in the 1930s. Due to the comparatively underdeveloped state of archaeological methodologies at the time and the relatively small number of individual discoveries, the finds were not immediately attributed to a new species. In 1976, anthropologists I. Koperns, M. Taieb, and D. Johanson led excavations in Hadar, Ethiopia, where they found over 240 hominid fossils from at least 35 individuals, including the famous partial skeleton named Lucy. In 2009, animal bones were discovered in the Lower Awash Valley in Ethiopia, near the same site where the team led by paleoanthropologist Zeresenay Alemseged had previously found a 3.3- million-year-old fossil nicknamed “Lucy’s baby” (Z. Alemseged et al. 2006, p. 296-300). The bones of one specimen were from an animal the size of an impala (or blackbuck antelope), while the others were from an animal closer in size to a buffalo. Both sets of remains showed signs of having been cut by sharp tools. The later discovery of stone tools with a corresponding date of 3.3 million years ago at Lomekwi 3 further supports the idea that A. Afarensis may have been a tool user nearly 1 million years prior to the emergence of the genus Homo (Harmand et al. 2015, p. 310). Though the chronology is certainly compelling, the butchered remains from the Lower Awash and the Lomekwi tools can’t yet be definitively attributed to A. Afarensis. In light of this uncertainty, we can turn to morphology for further supporting evidence.

One particularly morphologically informative example of A. Afarensis is the specimen AL 333/333w, which was found in Hadar, Ethiopia, in 1975. AL 333 exhibits numerous intermediate or ape-like features, placing it somewhere between pongoids and later hominids in terms of morphological development. Analysis of AL 333/333 w’s hands reveal a thumb-to-finger ratio similar to that of modern humans, though the rest of its morphology remains closer to the hands of chimpanzees, indicating a lower level of dexterity compared to later hominids as well as a number of hominid contemporaries (Alba et al. 2003, p. 225-254). However, it’s important to note that the fossil remains and footprints in Laetoli further indicate that A. Afarensis was bipedal, freeing up the arms and hands for activities unrelated to locomotion and opening up the possibility of tool creation.

Several isolated hand bones of Australopithecus Afarensis demonstrate a system of features that would have facilitated control of objects by the wrist-hand joint using the thumb and second and third ray-like fingers (Marzke & Shackley 1986). This combination suggests a capacity for tool use, specifically facilitating actions such as throwing and pounding with a three-jaw grip utilizing the thumb, index, and middle fingers. Precisely these kinds of pounding activities are attested to archaeologically from the bones discovered at Dikika in Ethiopia (dated to over 3.39 million years ago), which clearly indicate marrow extraction through the use of stones. In A. Afarensis, the grip of stone flakes between the thumb and index finger may have been further enhanced by the ability to bring the second metacarpal bone closer to the thumb.

The morphological features outlined above make a strong case for A. Afarensis being capable of producing and using stone tools like those found at Lomekwi. Still, the case isn’t closed. The definitive creators of the Lomekwian tools remain unknown, and new discoveries and research will be required to provide a clearer answer.

Australopithecus Africanus

Australopithecus Africanus was first described in 1925 by R. A. Dart based on the discovery of a juvenile skull known as the “Taung Child.” Dart proposed the hypothesis that bipedalism was characteristic of australopithecines because of the relatively anterior position of the foramen magnum on this skull (Ricklan 1987, p. 643-664). In 1978, Tobias F. and Clarke R. discovered a more complete Australopithecus skeleton known as “Cinderella” in the Sterkfontein area, a specimen which fortuitously also includes hand bones.

Cinderella’s bones were analyzed to determine the potential grasping strength function of A. Africanus. The metacarpals were found to be just as sturdy as those of modern humans, while the wrist extensor and radial wrist flexor muscles were probably even better developed than those found in H. Sapiens today. Of particular interest in the study of A. Africanus’ hand morphology is the consideration of the trabecula, an internal spongy structure enabling greater elasticity and flexibility of movement. The differential development of trabecular bone in the hands of various early hominids can suggest varying degrees of dexterity and functionality all on its own. However, the trabecular bone also rapidly remodels throughout the lifetime of an individual organism. This allows the trabecula to preserve traces of habitual activity occurring around the time of an organism’s death and subsequent fossilization. Based on this principle, researchers Matthew Skinner and Tracy Kivell have developed a pioneering method for reconstructing how early hominids used their hands.

The trabecular bone patterns in the thumb and palm (metacarpal and proximal phalanx) of A. Africanus were found to be compatible with the formation and fixation of power precision grips by placing external forces at the center of the palm, an activity associated with tool-making. However, the primitive morphology of the boat- shaped bone (Clarke 1999, p. 477-480) and pronounced curvature of the joint near the base of the thumb (Kibii et al. 2011, p. 510-517) indicate that the hand could not usually withstand large internal axial loads and transverse wrist forces, adaptations that are characteristic of more modern human hands. Despite these comparative drawbacks, a consideration of hand morphology alone by no means rules out A. Africanus as a potential tool user and producer.

Australopithecus Sediba

On August 15, 2008, Matthew Berger, son of paleoanthropologist Lee Berger from the University of the Witwatersrand, discovered the right clavicle of a new species at the Malapa site in South Africa. In 2009, an adult female skeleton was found, along with her hand, which contains a combination of Australopithecus-like and Homo-like elements (Berger et al. 2010). The hand exhibits a strong flexor apparatus associated with arboreal locomotion, and a long flexor of the thumb and short fingers associated with precise gripping and stone tool-making. The right arm of MH2 is almost complete, and several bones from the left arm are also present. The age of the discovery is 1,977 million years before present (Pickering et al. 2011, p. 1421-1423).

The anatomy of the thumb is significant for understanding any species’ ability to create tools. The combination of a broad apical bundle, a well-developed Long Flexor, and a narrow head of the metacarpal bone suggests that the tip of A. Sediba’s thumb may have been subjected to strong loads during flexion.

MH2’s hand bone is a mosaic of primitive and derived elements in a boat- shaped bone, similar to that of modern humans (Kivell et al. 2011, p. 1411-1417). The head of the first proximal phalanx of MH2 is usually less robust than in A. Afarensis, suggesting that this muscle is poorly developed. The softness of the bones of the thumb may also reflect the poor development of some internal muscle forms in MH2. Studies of modern humans producing Oldowan tools indicate that the thumb is subjected to large loads during the production of stone tools, suggesting that the thumb of A. Sediba was not subjected to the same type or frequency of loads as in other modern or later hominins.

The wrist and hand joints of A. Sediba are similar to those of earlier australopithecines, indicating that the index and middle fingers of MH2 did not experience the same type of loading as in later Homo (Pickering et al. 2011, p. 1421-1423). The finger phalanges and flexor apparatus show primitive and derived features related to powerful hand flexion and manipulation, such as an apical tuft that is more medially-laterally expanded compared to its contemporary hominin counterparts. A. Sediba is also characterized by the presence of pads on the fingers, necessary for distributing pressure during strong grasping and fine object manipulation.

The intermediate phalanges are smaller and more slender versions of the proximal phalanges, differing from those found in other hominins. The slender morphology of the phalangeal heads suggests that the MH2 digits were poorly adapted to resisting strong flexion loads on the dorsal side of the hand, which occur during powerful grasping movements associated with arboreal locomotion. The hand flexor apparatus is also reduced compared to the apparatus of A. Afarensis, but well- suited for arboreal behavior. The MH2 thumb is long (length of 1 metacarpal + 1 proximal phalanx = 6.4 cm), while the other fingers are short. The long thumb enhances the resistance of the fingers, facilitating object manipulation.

Taken as a whole, these morphological characteristics suggest an organism fully capable of producing and utilizing stone tools despite the retention of certain more primitive australopithecine traits.

Paranthropus Robustus and Homo Habilis

Despite bearing very distinct morphologies and possessing very different ecological adaptations, Paranthropus Robustus and Homo Habilis were living in the same spatiotemporal context roughly 2.5 million years ago. Until very recently it was universally believed that only Homo Habilis had the capacity to produce and use stone tools, namely, the Oldowan Industry. However, as we will see, morphological analysis of the hand suggests that Paranthropus Robustus may very well have been producing mode 1 stone tools as well.

The genus Paranthropus consists of early hominids with small brains and large teeth who are believed to have adhered to a predominantly vegetarian diet. This understanding of Paranthropus has led paleoanthropologists to all but automatically attribute stone artifacts found within the spatiotemporal range of Paranthropus to their contemporaries in the genus Homo, specifically, Homo Habilis.

The hand bones of Homo Habilis are best expressed in the specimen OH7, found in the Olduvai Gorge in Tanzania (Napier 1962, p. 409-411). Analysis of OH7's hands reveal a far more dextrous and developed fine motor capacity than the preceding australopithecines. This observation convinced Leakey, Tobias and Napier that Homo Habilis was the best possible candidate for producing the Oldowan Industry roughly 2.5-2.6 million years ago. This conclusion has been widely accepted, perhaps erroneously, and has since come to dominate the field. Despite the nearly universal belief that H. Habilis was solely responsible for creating the Oldowan Industry, morphological analysis of the hand reveals that this theory may be flawed. Despite Leaky, Tobias and Napier's initial assessment, H. Habilis' carpal bones in fact retain several primitive features. For example, OH7's fingers are long and curved like those of a chimpanzee, while the orientation of its thumb suggests an underdeveloped ability to firmly grasp and manipulate tools (Susman & Creel 1979, p. 311-331). This is not to say that H. Habilis could not have made tools, but rather that H. Habilis is by no means an indisputable or uniquely well-positioned candidate for tool production 2.5-2.6 million years ago. The very same features on which Napier and others based their belief that H. Habilis (OH7) made Oldowan tools can also be found in Paranthropus Robustus. Both species possess a comparatively sophisticated precision clamping ability. In other words, we have every reason to ascribe tool behavior to Paranthropus Robustus based on morphological capacity.

It was long believed that Paranthropus, with its small brain and vegetarian diet, lacked both the intelligence and the motivation to engage in tool making behavior. Furthermore, the absence of tool behavior was thought to have contributed to the ultimate extinction of Paranthropus in the Early Middle Pleistocene, though more recently discovered fossil remains refute this hypothesis (Trinkaus & Long 1990, p. 607-629).

Most conclusions about Paranthropus have been obtained from studies of cranial remains and endocasts of the brain. To date, the only postcranial fossils attributed to Paranthropus are seven bones from Swartkrans and four from Kromdraai. For a consideration of the functional capacity of Paranthropus Robustus' hand, and its potential for tool use, we can look to the carpal bones of specimen SKX 516, excavated in Sterkfontein cave and dated to 1.8 million years ago. Functional morphology suggests that SKX 516 was certainly capable of tool use.

Given the widespread belief that Paranthropus essentially lived on a vegetarian diet consisting of tough foods, it is possible that Paranthropus could have made tools from bone and stone for gathering and processing vegetables. If so, then perhaps Paranthropus invented or adapted tool behavior to a vegetarian way of life, while other early hominids applied their tools to more carnivorous dietary regimes. In any case, the material from Swartkrans requires a reassessment of the traditional view that the advent of tool behavior and "culture" distinguished the genus Homo from other early hominids, as well as that the absence of tool behavior (or morphological potential for it) led to the extinction of the genus Paranthropus.

Conclusion

As we have seen, each of the early hominid species discussed above seems to have been capable of producing and, to some extent, utilizing stone tools on the basis of functional morphological analysis. Intriguingly, each of the species above likewise retains ancestral features suitable for arboreal locomotion. This unlikely revelation requires significant further research and suggests that despite the great number of paleoanthropological insights made in recent years, we still have a number of misconceptions about early hominid behavior, as well as the trajectory and pace of hominid development, that need to be corrected.

If nothing else, we can now state definitively that the production of stone tools did not begin with H. Habilis or the emergence of the genus Homo. Rather, the morphological capacity for tool production and manipulation can be seen to have been present exceedingly early in the process of hominid development. Based on the morphology of the hand we now know that Australopithecus Afarensis, Africanus & Sediba were each capable of manipulating stone tools, and, in light of the finds at Lomekwi 3, likely made them as well.

We have also shown through functional morphological analysis that Parantropus Robustus could very well have been making and using Oldowan tools alongside or even in lieu of H. Habilis some 2.5 million years ago, a realization that dramatically recolors our understanding of the relationship between the genus Homo and our early hominid contemporaries.

Clearly, morphological analysis of hominid hands has demonstrated that the development and use of tools is much more complicated than previously thought. We have transformed our conception of H. Habilis as the sole master of stone tools to arrive at a much broader lineup of possible tool-producing early hominids. The widespread capacity for tool-use and production among early hominids has huge implications for our attribution of particular lithic toolkits to specific species in the archaeological record, and certainly forces us to reconsider the place and role of tool- use in the development of our species.

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Морфологія руки ранніх гомінід в контексті знаряддєвої діяльності

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В даній статті розглянуто тему морфології кісток рук ранніх гомінід. Метою є відповісти на питання: «Чи є рід Хомо єдиним, який був здатним створювати знаряддя?».

Нові дослідження висувають гіпотези, які суперечать застарілим науковим висновкам та вказують на можливість того, що й інші представники гомінід, такі як австралопітеки та парантропи були здатні до виготовлення інструментів.

Відкриття археологічної пам'ятки Ломекві 3 та кам'яних інструментів, що датуються віком 3.3 мільйони років тому, додало багато нових запитань сучасній науці, оскільки вік згаданих артефактів передує появі першого Homo. Це змушує нас заново переглянути дослідження, що стосуються ранніх гомінід, щоб краще зрозуміти хто саме був творцем цих інструментів та чи є це унікальною рисою саме роду Homo.

Першим у статті буде розглянуто Австралопітека афарського. Його датування як раз збігається з датуванням кам'яних інструментів з Ломекві 3. Аналізуючи кістки його руки, ми можемо зробити висновки про його здатність виготовляти інструменти. Проте, у той же час австралопітек має також мавпячі риси. Аналогічним чином ми можемо висловитися про Австралопітека африканського і Австралопітека седібу. Однак тут виникають проблематичні питання, адже африканців було відкрито доволі давно і ми стикаємось з певним упередженим ставленням щодо них, а також неточністю в їх першопочатковому дослідженні. Найкраще описаним був Австралопітек седіба, знайдений в 2008 році. Тут кількість отриманої інформації дозволяє нам робити більш значущі припущення про його здатність до створення кам'яних інструментів. Питання викликають у нас хабіліс й парантроп, оскільки обидва ці ранні гомініди були знайдені в тій же місцевості, де

і олдувайські знаряддя. Та якщо ми критично поглянемо на аналіз їх верхніх кінцівок, то ми не побачимо великої різниці між ними. У деяких аспектах рука парантропа виглядає більш розвиненою там прогресивною.

Отже, стає очевидною необхідність переоцінки раніше відкритих залишок ранніх гомінідів і пов'язаних з ними археологічних місцезнаходжень. Ці переоцінки можуть надати нам нові погляди на здатність ранніх гомінідів створювати інструменти і допомогти нам зрозуміти еволюцію створених ними інструментів.

Ключові слова: Археологія, Палеоантропологія, Еволюція, Австралопітек Парантроп, ранні гомініди.