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A *Homo Erectus* Hyoid Bone: Possible Implications for the Origin of the Human Capability for Speech

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A B S T R A C T

Authors describe a hyoid bone body, without horns, attributed to Homo erectus *from Castel di Guido (Rome, Italy), dated to about 400,000 years BP. The hyoid bone body shows the bar-shaped morphology characteristic of Homo, in contrast to the bulla-shaped body morphology of African apes and Australopithecus. Its measurements differ from those of the only known complete specimens from other extinct human species and early hominid (Kebara Neandertal and Australopithecus afarensis), and from the mean values observed in modern humans. The almost total absence of muscular impressions on the body's ventral surface suggests a reduced capability for elevating this hyoid bone and modulating the length of the vocal tract in* Homo erectus. *The shield-shaped body, the probable small size of the greater horns and the radiographic image appear to be archaic characteristics; they reveal some similarities to non-humans and pre-human genera, suggesting that the morphological basis for human speech didn't arise in* Homo erectus.

Key words: *paleoanthropology, articulate language evolution, Castel di Guido*

Introduction

The origin of human language, and in particular the question of when our ancestors acquired the ability to speak, is of crucial interest to anthropologists. Many previous studies of laryngeal/basicranial morphology suggest that during the Middle and Upper Paleolithic *Homo sapiens* was incapable of language/speech, but, despite its importance, the topic remains one of great controversy, with the answers largely based on inference. In fact, the records of fossil hyoid bones in the line of human evolution are very limited. We have only two examples: the description of the hyoid bone body found at Dikika,Ethiopia, assigned to *Australopithecus afarensis*[1], and the description of a complete hyoid bone of a Neandertal male found at Kebara, Israel[2]. Consequently, the present description is only the third published report on this very restricted topic, and the most ancient one pertaining to the genus *Homo*.

Materials and Methods

The Castel di Guido hyoid bone body is part of the largely incomplete skeleton of an adult Middle Plieistocene human individual, dating to 400,000 years B.P., which was unearthed by Prof. Antonio Mario Radmilli and co-workers during the excavation (1980–1990) of an Lower Paleolithic deposit located a few kilometres north of Rome on the ancient Roman consular road, the Via Aurelia[3]. Anatomically, the Castel di Guido 1 individual (CdG-1) has been described as a typical adult male *Homo erectus*[4], and was probably one of the last representatives of this species in Europe. A recent re-appraisal of the bone collection of Castel di Guido fossils was carried out to analyse micro-traces on the bone surfaces, and to demonstrate artificial cortical scraping due to possible cannibalistic activities[5]. During this very detailed examination, which included stereomicroscopic analysis, the authors identified a very small bone fragment that attracted our attention because of its general shape, morphology, structure, and size. This tiny sample, previously unclassified, belongs to the un-cataloged materials collected on the site of Castel di Guido by Ernesto Longo, the first student who discovered the Acheulean site at Castel di Guido; unfortunately, he died soon afterwards in an accident.

First of all, we have some doubts about the true original anatomic position of the small bone fragment de-

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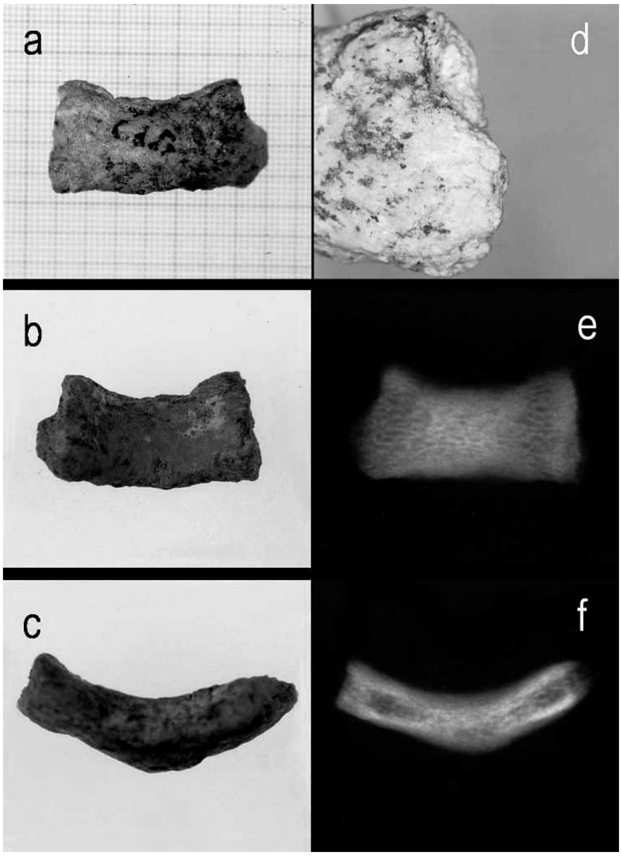

Fig. 1. Hyoid bone of Homo erectus from Castel di Guido 1: ventral (a), dorsal (b) and superior views (c); superior-lateral left margin of the body showing non-fusion of the left greater horn (d); radiographs: frontal (e) and superior (f) views.

scribed here: the rectangular shape, the very thin, concave appearance, the concave aspect of the inferior lateral corners, and, above all, the presence of two well-defined, separate facets at the level of the superior-lateral corners, are all morphologies strictly consistent with the interpretation of this bone fragment as the nearly complete body of a hyoid bone, similar to the modern human hyoid (Figure 1). The specimen was observed under the stereomicroscope and subsequently was examined radiographically with a mammographic screen at very low density radiation.

Description of the Specimen

The right margin of the body is broken, and stereomicroscopic observation reveals the cancellous structure inside the bone under a very thin layer of cortical bone. We are certain that the horn on the left side was not fused with the body (on the right side, the corresponding region is broken); this feature is common in collections of modern human hyoid bones[6], and has also been described in the Neandertal hyoid bone as well as in modern chimpanzees[7–9]. The hyoid bone from Castel di Guido doesn't show any evidence of muscle attachment and appears smooth; it differs both from the Neandertal hyoid[2], and from the anatomical model of the modern human hyoid, although there is a large range of variation of the morphology of the muscular attachment sites on the hyoid bone. Furthermore, our fragment is also quite different from the only described hyoid bone body assigned to *Australopithecus afarensis* from Dikika, Ethiopia, recently described by Alemseged at al.[1].

The ventral surface is regularly rounded, quite convex, and has a rounded, prominent median crest; on this surface there is no evidence of the roughness or fossae related to the attachment of the geniohyoid muscles and the other supra-hyoid muscles. The area of attachment of the homohyoid muscle at the level of the inferior-lateral corner is well preserved only on the left side, where it is deeply indented, rounded, and concave, but without roughness or depression. At the centre of the inferior margin there is a small tubercle between the insertions of the thyrohyoid muscles. The dorsal surface is homogenously remarkably concave, and without roughness. The superior-lateral left corner shows two distinct small areas of cartilaginous attachment: the medial one is for the lesser horn, and the lateral one, which is more extended, is for the greater horn. The small size of the articular facets on the superior-lateral corners of this body suggests that the greater horns were small and thick, like those of modern chimpanzees[7]. The stereomicroscopic observation of the supra-lateral right corner shows a well-developed facet for the greater horn; this surface is concave and rough, and surrounded by a small bony ring.

In Figure 2 the dimensions of the Castel di Guido hyoid bone are compared with the hyoid bones of a large sample of anatomically modern humans and the only other hyoid bone known from fossil man, the Kebara hyoid[2], and the only early hominid hyoid bone, from

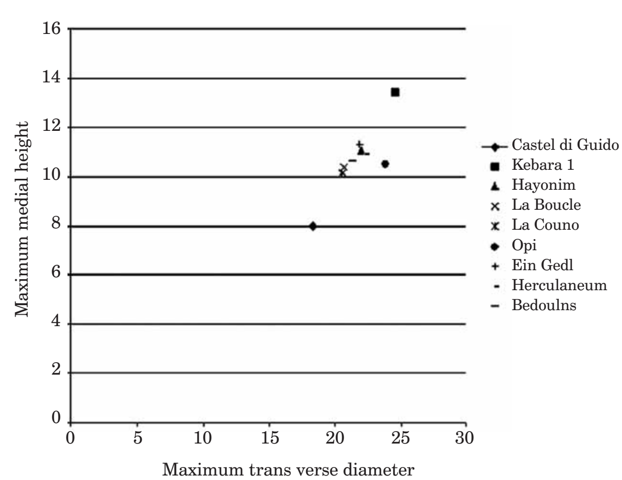

Fig. 2. Bivariate plot of the maximum transverse diameter and the maximum medial height. According to the mean value of the ratio between maximum transverse diameter and maximum medial height, the Castel di Guido hyoid bone differs significantly with respect to the two known specimen of fossil hyoid bones (the Australopithecus afarensis from Dikika and the Neandertal from Kebara), and to modern (both living and ancient) humans hyoid bone.

Dikika[1]. The principal measurements of the body reveal some differences between the Castel di Guido hyoid bone and both the fossil and the modern human samples. The Castel di Guido hyoid bone body is smaller in its general dimensions: the maximum transverse diameter and, in particular, the maximum medial height, are less than the mean values of these dimensions in either modern or fossil humans. The Castel di Guido hyoid bone is also very different from the Dikika hyoid bone because it is larger in its general dimension and its general shape. In particular, the Castel di Guido hyoid bone is thicker than the Dikika hyoid bone, so it seems more robust. In addition, from the morphological point of view, the Dikika hyoid bone body is bulla-shaped, in contrast to the Castel di Guido hyoid bone body, which is bar-shaped.

Although the Castel di Guido hyoid bone measurement do fall within the range of variation of modern humans, the ratio between the maximum transverse diameter and the maximum medial height is significantly different (Figure 2), and shows that the body of Castel di Guido hyoid is more developed in the transverse dimension than that of either fossil or modern man. The depth of the dorsal surface is relatively well developed, and at the centre of the dorsal surface there is a true cavity that resembles those found in the bones of modern chimpanzees. The radiographic picture also shows an internal structure resembling that of non-human primates[10], which is quite different than that of the hyoid bone body in modern humans[11]. In particular, the arrangement of the trabeculae in the internal structure differs from that of modern humans, with an increase in density that corresponds with the well developed medial crest of the ventral surface, and no areas of radiotransparency present lateral to the median line, in correspondence with the attachment area of the geniohyoid muscles.

The first, and – until now – the only fossil human hyoid known (Kebara 2) is almost identical in size and shape to the hyoid of present-day populations, suggesting that there has been little or no change in the anatomy of the visceral skeleton (including the hyoid bone, middle ear ossicles and, inferentially, the larynx) during the past 60,000 years of human evolution; this similarity allows us to hypothesise that Neanderthals were able to speak[2,10,12,13]. The Dikika hyoid bone body is from a young *Australopithecus afarensis* individual (DIK-1-1). The general shape of the hyoid body displays a typical African ape morphology: a concave shape, thin, narrow and high. From the anthropometric point of view, this specimen is not useful for comparison to our specimen because the Dikika hyoid bone is from a juvenile individual [1]; its maximum transverse diameter is about 25 mm, and the maximum medial height is 17 mm. Consequently the body index is about 147, very different from the medial value for both the extant humans and of the fossil hyoid bone from Kebara.

The morphology of the Dikika hyoid bone is as yet not fully described as the ventral face of the body is still covered with rock; nonetheless, this hyoid bone body shows similarities with *Pan* and *Gorilla* hyoids, suggesting that the bulla-shaped body represents the primitive condition for African apes and pre-humans, rather than the more shallow, bar-like body shown by both modern humans and *Pongo*.

Discussion

On the basis of the reported description and comparison of our specimen with modern humans and fossil pre-human and human records, we can conclude that, from morphologic, dimensional, and structural standpoints, the body of the hyoid bone of the Castel di Guido *Homo erectus* differs from both Neandertals and anatomically modern humans. The general shape of the Castel di Guido hyoid bone is very similar to both chimpanzee hyoid bones and to the only known *Australopithecus afarensis* hyoid bone. With respect to the Dikika specimen, the hyoid of Castel di Guido is larger and relatively shorter.

In fact, the hyoid bone body of the *Homo erectus* is developed primarily in the transverse direction, assuming the so-called »bar-shape«, in contrast to the so-called »bulla-shape« hyoid body. The bar-shaped hyoid bone body is characteristic of extant humans and of extant *Pongo*, as well as of the Kebara specimen. The bulla-shaped hyoid bone is characteristic of extant *Pan* and *Gorilla*, the two living genera that possess the air sac, as well as of the only fossil hyoid bone body from *Australopithecus* (the Dikika specimen). The bulla-shaped body almost certainly reflects the presence of laryngeal air sacs characteristic of African apes[14]. However, the function of these structures is not well understood[15]. In addiction, the *Homo erectus* hyoid bone is without impressions from the attachment of the major supra-hyoid muscles, whose activity modulates the high end of the vocal tract together with the sub-hyoid muscles [16]. The dorsal face is deeply indented and the ventral face protrudes in a robust, rounded median crest, making this hyoid bone resemble those of adult chimpanzees [17], in which the greater horns remain non-fused also in the older subjects.

We know that there is a considerable distance between morphology and function; as an extreme example, even parrots are able to speak despite the anatomy of their phonetic organs being obviously very different from that of the human larynx. Even so, we know that there are no anatomical differences between the hyoid bones of Neandertals and modern humans[18], and this evidence has been considered sufficient to demonstrate that Neandertals were capable of language/speech, in accordance with the cultural remains and paleoneurological evidence[19–21]. To the contrary, there are some differences in the anatomical structure of the hyoid bone of *Homo erectus*, and the related inference would be that the visceral skeleton (larynx included) has changed in structure, position, form, relationships, and size since the anatomical and cultural stage corresponding to *Homo erectus*. If, indeed, this inference is warranted, the morphological basis for human speech capability appears to have fully developed only during the Middle Paleolithic, with the rise of the *Homo sapiens*, and with his European variant, *Homo neanderthalensis*.

This conclusion agrees with the conclusions based primarily on the studies of basicranial morphology[20], which consider that the speech capability is characteristic only of *Homo sapiens*. At the same time, we can state that the first large migrations out of Africa, and Man's conquest of the entire Old World, during the biological stage of *Homo ergaster* (earlier) and *Homo erectus* (later), was achieved without possession of an articulate language.

Conclusion

In summary, the general morphology of the *Homo erectus* hyoid bone body displays a bar-shaped morphology, characteristic of both extant humans, the only known fossil specimen from the genus *Homo* (Kebara), and the extant genus *Pongo* (Figure 3). This shape seems to confirm that the earlier phases of human evolution, not associated with the capacity for speech, were characterized by a bulla-shaped hyoid body. On the basis of the few fossil hyoid bones available for examination, it seems reasonable to admit that the bar-shaped hyoid body is a characteristic of the genus *Homo*. In addition, the small anatomical differences between the *Homo erectus* of Castel di Guido and *Homo sapiens* hyoid bones consist primarily of a few impressions from the attachment of the major supra-hyoid muscles, whose activity modulates the high end of the vocal tract together with the sub-hyoid muscles; this muscular deficiency may reflect a minor ability of *Homo erectus* to communicate in an articulate language. Naturally, it is necessary to find other *Homo erectus* hyoid bones to confirm our hypothesis.

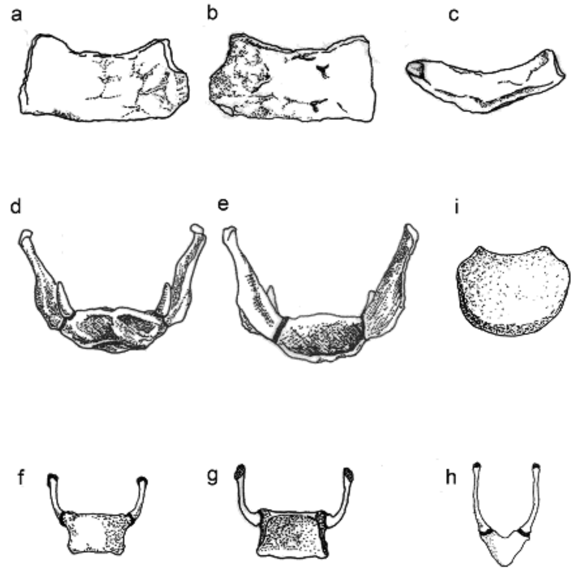

Fig. 3. This drawing compares the general morphology of the Homo erectus from Castel di Guido(CdG-1) hyoid bone (a, b, c), with the bones from the Neandertal man from Kebara (Kebara-2) hyoid bone (d, e), the extant Pan troglodytes hyoid bone (f, ventral view; g, dorsal view; and h superior view), and the Australopithecus afarensis from Dikika (DIK-1-1) hyoid bone body (i, infero-posterior view).

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JEZIČNA KOST *HOMO ERECTUSA*: MOGUĆE IMPLIKACIJE NA PORIJEKLO ČOVJEKOVE SPOSOBNOSTI GOVORA

S A Ž E T A K

Autori opisuju tijelo jezične kosti bez rogova, kakva se pripisuje Homo erectus-u iz Castel di Guido (Rim, Italija), datirane na otprilike 400,000 godina prije sadašnjosti. Tijelo jezične kosti pokazuje štapićastu morfologiju karakterističnu za rod Homo za razliku od ovalnog oblika nađenog kod afričkih majmuna i roda Australopithecus. Dimenzije kosti kod jedinih cjelovitih primjeraka izumrlih ljudskih vrsta i ranih hominida (Kebara Neandertalac i Australopithecus afarensis), i prosječnih kostiju modernih ljudi, razlikuju se. Gotovo potpuno odsustvo mišićnih otisaka na prednjoj površini tijela kosti ukazuje na smanjenu mogućnost podizanja jezične kosti i modulacije vokalog trakta kod Homo erectusa. Štitasti oblik tijela kosti, vjerojatno manja veličina velikih rogova i radiografske slike ukazuju na arhaične karakteristike; otkrivaju neke sličnosti s vrstama starijim od roda Homo sugerirajući da morfološka osnova ljudskog govora nije nastala kod Homo erectus-a.