Kostenki 14: the unusual earliest Eastern European Cromagnon in light of palaeoradiology

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One of the earliest in Eastern Europe anatomically modern man Kostenki 14 was particular from morphological point because of his low stature. Radiological research provided with use of microfocus digital X-ray as well microCTscanning revealed additional peculiarities of this individual. It was detected that Kostenki 14 male had exceptionally heavy skeleton because of thick walls of tubular bones and reduce of medullary space. Symmetrical location of medullary stenosis, which is complete in small tubular bones of hands, indicates systemic bone condition, probably, hereditary disease. The paper considers differential diagnostics based on modern clinical, radiological and genetic data. The morphological picture of Kostenki 14 corresponds to modern inherited diseases manifesting as elevated bone density with diaphyseal involvement. The deposition of solid bone in space of medullary canal is clear seen on the microCT slices of small tubular bones. The skeletal condition indicates reduced secretion of thyroid hormone, i.e. hypothyroidism. In row of hereditary disorders with diaphyseal involvement Kenny Caffey syndrome is associated with clinically detected growth retardation, typical for K14 man. A Palaeolithic hunter with hereditary disease like Kenny Caffey syndrome could suffer from anemia, back pain, often convulsions, parhesthesia or even from ophtalmologic disorder. Accomplished hyperopia could be useful for distant animals watching, but provided risk of traumas in short distant manipulations.

Key words: Upper Palaeolithic, Kostenki 14, radiology of bones, palaeopathology, medullary stenosis

Introduction

Modern radiological techniques mark a new stage in the morphological study of extant and fossil humans, offering opportunities to work with fragmentary or better preserved material. CT scanning and micro tomography help evolutionary anthropologists to get digital 3D copies of unique objects (fossil teeth and bones); to study inner structure by nondestructive methods or to collect large set of comparative data.

Earlier using micrfocus X-ray we tried to differentiate between “archaic” and “modern” samples in degree of trabecular system development and mineral density [Mednikova, Potrakhov, Bessonov, 2012, 2013]. Microfocus X-ray is a perspective approach to evaluation of bone condition in pathological and destructive processes, which helps to describe small and low-contrasting details of images with magnification and in good quality. We used the method to study inner structure of small tubular bones (mainly, manual phalanges) from representatives of Middle Pleistocene (Neanderthals from Okladnikov cave and from Kiik-Koba shelter), Upper Palaeolithic (Sunghir 1 male) and living Homo.

Radiological data were also used in description and interpretation of a specific superficial injury on the Upper Palaeolithic human calvarium. Skeletal remains attributed to Homo were discovered in 1959 by the expedition headed by A. N. Rogachev at the Telmanovskaya site (Kostenki 8). Microfocus radiography has established intravital character of the operative intervention in the centre of the frontal bone, most probably a symbolic trepanation [Mednikova *et al.*, 2012].

Microfocus digital X-ray and computed tomography were also applied in research of built of small tubular bones of Sunghir man [Mednikova, 2012]. Study of hand of fossil hominids traditionally focuses great attention of evolutionary anthropologists. Hand of the Upper Palaeolithic man Sunghir 1 was initially described by E.N.Khrisanfova. General sapient features combined with some peculiar, even Neanderthal those. The similarity of Sunghir male with early modern Shkul 4 was pointed, as well partial similarity with Kiik-Koba Neanderthal. Radiological approaches improved methods of analysis of fossil remains. New comparative materials of the Middle and the Upper Palaeolithic Ages can be used. Recent publication had goal to describe new morphological information about inner and external built of phalanges in context of comparative data. By macromorphological patterns, including absolute sizes, relation of phalanges of pollex, hand of Sunghir shows features of modern anatomy. Hypertrophy of transversal diaphyseal sizes had analogies in some Neanderthal forms. Microfocus digital X-ray corrected knowledge about level of negative influence in childhood, indicated 6 Harris lines in the image of distal phalanx of the 3rd ray. Widening of distal phalanges, robust transversal and lateral ridges of palmar surface of right proximal phalanx, as well massive trabecular metaphyseal structures of middle phalanx reflect intense biomechanical influence, mainly, for the right hand. CT scanning discovered exceptionally robusticity of walls of right tubular bones, comparable with Neanderthal values. But corticalisation of left hand bones is smaller, and large postcranial bones of the same individual have relative gracile walls at all. That means, some «Neanderthal» or «archaic» traits of Sunghir 1 generally reflect occupational stress for the right hand.

Recently a new study was devoted to morphological descriptions of hand remains of other Upper Palaeolithic human from Eastern Europe [Mednikova, Moiseev, Khartanovich, 2016]. Both external and inner structure of small tubular bones of Kostenki 14 male was described. The purpose of current paper is to highlight some unusual features met during radiological examination of K14 bones.

Patterns of material and methods

In 1954 during excavations of the multi-layered Upper Palaeolithic site Kostenki 14 under the floor of the third cultural layer were found well preserved human remains "in anatomical order". Recent Radiocarbon dating makes Kostenki 14 one of the oldest fossils of Anatomically Modern Humans from Europe [Douka *et al.*, 2010; Seguin-Orlando *et al.*, 2014].

Data of palaeogenetics [Seguin-Orlando A., *et al*, 2014] indicated that K14 male belonged to meta-population very successfull from evolutionary point. He shares a close ancestry with the 24,000-year-old Mal'ta boy from central Siberia, European Mesolithic hunter-gatherers, some contemporary western Siberians, and many Europeans, but not eastern Asians. Additionally, the Kostenki 14 genome shows evidence of shared ancestry with a population basal to all Eurasians that also relates to later European Neolithic farmers. The main ancestral components proposed for contemporary Europeans, including the Middle-Eastern component commonly attributed to the expansion of early farmers within Europe, were likely already genetically differentiated and related through complex gene flow by the time of K14. His nuclear DNA K14 indicates relatively recent hybridization with Neanderthals, because the length of Neanderthal tracts was higher in K14.

K14 male was particular from morphological point. K14 tubular bones were short with relatively gracile diaphyses. In comparison to other early European CroMagnons male Kostenki 14 had unusual low stature: 159-160 cm by Trotter-Gleser formulae (for Negroids). The closest geographically and chronologically male Sunghir 1 had stature from 175,3 till 184,3 cm [Trinkaus *et al*, 2014, p.178].

In our study measurements of tubular bones of K14 were taken by digital electronic caliper. The inner structure was investigated by microfocal digital X-ray equipment PRDU and by microtomography (XRADIA 3D digital microscope).

Bony walls were measured at the midshaft level. Features of cross-sectional geometry were estimated according to ellipse formulae.

Results

The complete preservation of right hand elements gave opportunity to estimate ratio of lenghts of the 2nd and 4th fingers 2D:4D, which was 93,32 [Mednikova, Moiseev, Khartanovich, 2016]. The value is identical the value for the right male hands in the control William Bass collection. That means, testosterone secretion in this Upper Palaeolithic male during the 13 week of in utero development was in range of normal values.

The macromorphological examination of K14 hand indicates the external gracility. Manual elements K14 externally show the typically "anatomically modern" built. Moreover, K14 is at the centre of variability of European CroMagnons, supporting data of genetic expertise.

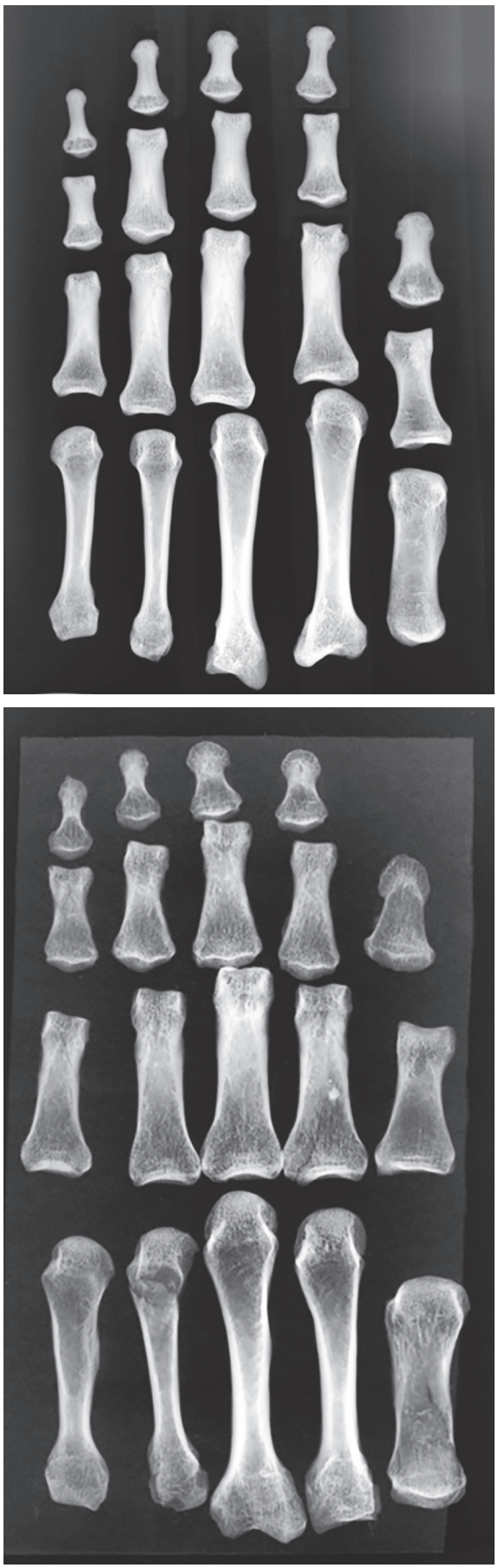

Figure 1: *Microfocus X-ray films of right hands of two Eastern European Upper Palaeolithic humans.*
A. Kostenki 14, young adult.
B. Sunghir 1, around 40 years old.

There are till 7 Harris lines on the X-ray films of manual bones, better seen in lateral projection. That means a number of growth disruptions till 16,5 years, [time of fusion for modern boys, Schaefer *et al.*, 2006, p.228]. So, the level of episodic stresses in Kostenki 14 and Sunghir 1 seems to be comparable.

By radiological methods were also discovered atypical patterns of the inner structure of many tubular bones [Mednikova *et al.*, 2016]. They are presented in multiple diaphyseal medullary stenosis of all distal, middle and left proximal manual phalanges. So, indices of corticalisation (%CA) of bones of the 3rd ray in males Kostenki 14 and Sunghir 1 differ strongly. Thickness of the walls of the diaphysis of tubular bones is usually explained as the result of hypertrophy caused by physical activity, as shown by a range of empirical evidence [Ruff *et al.*, 1993], but it seems unlikely that mechanical stresses could have been so radically different for two CroMagnons – young adult K14 and mature man S1 (Fig.1).

In opposite to expectations, Kostenki 14 had exceptionally heavy skeleton. Symmetrical location of medullary stenosis indicates systemic bone condition, probably, hereditary disease.

Discussion

Medullary stenosis, diagnosed using radiological methods, is a rare condition. In the palaeontological record it has been found earlier in Homo erectus, in which the cortical layer of the femur was elevated to statistically significant values [Kennedy, 1985]. "Additional" bone material deposits were present in long bones of H.erectus not only on the side of the periosteum, but on the surface of the endosteum, closing off the bone marrow space.

Another case of medullary stenosis was described for Neanderthal distal phalanx from level 12 of Denisova Cave, dating, as minimum, by 60-50 thousands years BP. [Mednikova, 2013].

A classification of congenital osteosclerosis types with elevated bone density has been developed for modern H. sapiens based on genetic data and adjusted with clinical, morphological and radiological observations [Vanhoenacker *et al.*, 2000]. For example, displasias with increased bone density today include: osteopetrosis (4 types), axial osteosclerosis (2 types), pycnodysostosis, osteosclerosis Stanescu type, osteopathia striata (2 types), sponasrime dysplasia, melorheostosis, osteopoikilosis, mixed sclerosing bone dysplasia.

The morphological picture of K14 corresponds to modern inherited diseases manifesting as elevated bone density with diaphyseal involvement. The deposition of solid bone in space of medullary canal is clear seen on the micro CT slices of small tubular bones (Fig.2). The skeletal condition indicates reduced secretion of thyroid hormone, i.e. hypothyroidism.

Among diseases with increased bone density with diaphyseal involvement there are dyaphyseal dysplasia Camurati Engelmann, craniodiaphyseal dysplasia, Lenz Majevski displasia, endosteal hyperostosis (4 types). But a special attention should be payed to Kenny Caffey dysplasia [Caffey, 1967; Kenny, Linarelli, 1966], which can be both autosomal-dominant and autosomal recessive, with chromosomal locus 1q42-q43 [Kelly *et al.*, 2000, p. 63–64].

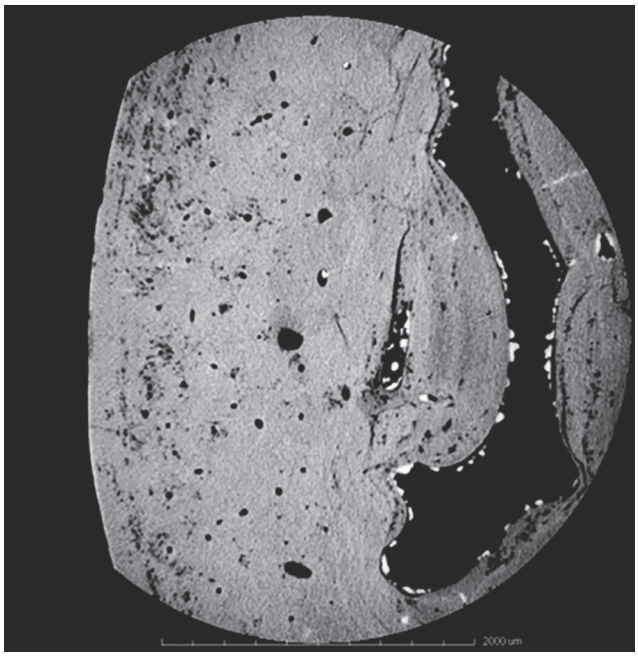

Figure 2: *Kostenki 14. Microthomography of the dorsal wall of the middle phalanx. The deposit of bone inside the medullary canal is visible.*

Kenny Caffey syndrome is associated with a number of manifestations. Clinically detected growth retardation (short stature in adult forms – 90%), craniofacial anomalies, small hands and feets, hypocalcemia, hypoparathyroidism. Radiologically detected cortical thickening of tubular bones with medullary stenosis (100%). Absence of diploe in cranial vault was reported. 36% of patients, who had hemoglobin measured, were found to be anemic. 14 from 20 modern patients have hyperopia – a sort of long sight, which doesn't permit to focus on close objects. A case study of modern man, 24 years with Canny-Caffy syndrom demonstrates possible complications for male Kostenki 14, who was the same biological age [Larsen *et al*, 1985]. A young man "was evaluated for back pain and small testes at the University hospital. He…was found to have short stature, multiple low serum calcium determinations with elevated phosphorus level… His birth weight was six pounds, 11 ounces…his anterior fontanelle closed at age two and half years. He wore glasses at age two…He underwent puberty at age 13 without any subsequent sexual disfunction or maturation delay…His [adult] height of four feet, 11 and three fourth inches, with a weight of 165 pounds and normal upper-to-lower segment and arm span-to-height ratios…High hyperopia." [Larsen *et al.*, 1985, p. 1025].

Clinical data show that females with syndrome have no limitations of fertility although it creates serious problems of health of the offsping. For 20 pregnancies of

mothers with syndrome only 9 infants were born healthy. There are non-direct data of limited male fertility. Male-to-male (or by paternal line) transmission is lacking. Only 3 males have been described at an age of sexual maturity. One died at age 19 without history of paternity, another was a 19-years old with a low IQ and cryptochidism, again without history of paternity. The third, at age 40, was unmarried and without children [Ibid. P.1028].

The main problem for a Palaeolithic hunter with similar hereditary disease (in addition to back pain, often convulsions, parhesthesia) could be ophtalmologic disorder. Hyperopia could be useful for distant animals watching, but provided risk of traumas.

Conclusion

In spite of distribution of serious genetic disorder, probably, reduced male fertility, representatives of meta-population to which Kostenki 14 belonged, were very successful from evolutionary point. Perhaps, that was connected with human system of social connections and with support of relatives with limited opportunities. The previously reported case of Upper Palaeolithic Romito dwarf supports this idea [Tilley, 2015].

The same mechanism of the reduced male fertility was proposed for elimination of male off-spring after hybridization with Neanderthals, and it should be stressed that Kostenki 14 male had longer Neanderthal tracts.

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