



EUGEN STROUHAL

BIOLOGICAL AGE OF SKELETONIZED MUMMY FROM TOMB KV 55 AT THEBES

ABSTRACT: The on-going discussion by Egyptologists and anthropologists concerning the fate of Akhenaten's body, has allegedly been solved recently by his identification with the skeletonized mummy originally found in 1907, in the rock of Tomb 55 in the Valley of the Kings at Thebes (Hawass et al. 2010). By a meticulous re-examination of the male skeletal remains from tomb KV 55 by the author of this paper, a number of features demonstrate that his biological age at death was in the range of 19–22 years, strengthened by the complete absence of even incipient dental or osseous age-dependent pathological changes. Since Akhenaten's reign was at least 17 years according to Egyptological sources, he could not have started to reign as a 2–5 year old child. On the other hand, his elder brother Smenkhkare, if he died as a 19–22 year old, could easily have reigned for 3 or more years. The striking resemblance of Tutankhamun and the man from KV 55 confirms highly probability of their brotherhood and the identification of the latter as Smenkhkare.

KEY WORDS: Tomb 55 – Thebes – Egypt – Skeletal anthropology – Age features – Identification

INTRODUCTION

In January 1907 Edward R. Ayrton (1910), working in the concession of Theodor E. M. Davis in The Valley of the Kings, found a small, single-chambered roughly-hewn rock tomb KV 55 containing a shrine of Queen Tiye and a coffin. The almost fully skeletonized mummy was laid with its right arm straight down by the side and its left arm folded with its hand on its chest. This position was believed to be typical for royal female mummies. Soon after the discovery, the tomb was visited by two surgeons (Dr. Pollock of Luxor and a visiting American obstetrician), who most probably respected the views of the Egyptologists who had excavated the remains and, being not trained in anthropology, agreed with them that the skeletonized body was "without doubt that of a woman". In fact Queen Tiye's body had long ago been removed from the tomb or perhaps was never even buried there. Her body was later identified with the mummy of the "Elder Lady" found in Tomb KV 35, belonging to her husband Amenophis III (Reeves 1981).

The bones from KV 55 were sent to Cairo Museum (Catalogue Général No. 61076) for examination by Grafton

Elliot Smith in 1908. He determined them to be the skeletal remains of a young male aged 25–26±2 or 3 years. Taking into account the unusual shape of the skull, and, after consulting the pathologist A. R. Ferguson, he suggested that it had signs of hydrocephalus, and admitted the possibility that the process of ossification could have been delayed by that disease (Elliot Smith 1910). This could have been his way of reconciling the young age of the skeleton with the fact that in the tomb some burial goods were found inscribed with the name of "Khouniatonu" (as the name of Akhenaten was read at the time), especially thin gold sheets or bands in which the mummy was allegedly wrapped (Maspero 1910: XIII, Davis 1910: 2). With this conjecture Elliot Smith (1912) finalized his analysis of the remains of mummy No. 61075 in the "Catalogue Général" of Egyptian Antiquities in the Egyptian Museum in Cairo as follows: "We have the most positive evidence that these bones are the remains of Khouniatonu". However, the very existence of the inscribed mummy bands was disproved decisively by a posthumous publication of Helck (2001: 17), being identified as gold sheets which collapsed on the mummy from the interior of the coffin. The remnants of



FIGURE 1. Skull of the man from KV 55 (CG 61075) in frontal view. Photo E. Strouhal.

erased cartouches apparently belonged to the short-reigned pharaoh Smenkhkare (1334–1331 BC, Engelbach 1931).

This marked the beginning of a long-lasting controversy among Egyptologists. Those who took into account the discrepancy between the anatomical determination of the very young age at death of the body from KV 55 and the assured length of Akhenaten's reign (1351–1334 BC), attributed the mummy to his successor on the throne of Egypt and probable elder son Smenkhkare (Engelbach 1931, Derry 1931). Other Egyptologists, beginning with Weigall (1922) followed Elliot Smith's identification of Akhenaten.

After almost a century of ongoing discussions, the most recent monograph on the iconography of the Akhetaton colossi and other depictions of the King (Manniche 2010: 142, 148) concluded that: "The identity of the body in KV 55 remains controversial."

To our great surprise, in a recent oral presentation during the 18th European Meeting of the Paleopathology Association in Vienna, A. Zink presented the results of a genetic (DNA based) study of a 5-generation lineage of Tutankhamun's ancestors, stating "the mummies from the tombs KV 55 and KV35YL (considered to be Akhenaten and Nefertiti) were identified as the parents of Tutankhamun" (Zink *et al.* 2010). The same reasoning is contained in the paper by Z. Hawass *et al.* (2010), which

will be discussed later. This very late revival of Elliot Smith's (1910, 1912) erroneous identification stimulated me to write the present paper, which is based solely on anthropological arguments from my study of the human remains from Tomb KV 55.

A profusion of papers and books dealing with the problem from the Egyptological point of view were recently analysed by Helck (2001) and Manniche (2010) and do not need to all be quoted in this paper. Also, the vast literature concerning the different diseases and syndromes attributed by medical specialists to Akhenaten, but never shown in the skeleton from Tomb KV 55, will be avoided. Our study is limited strictly to an analysis of the normal (physiological) features of the skeleton, highlighting in italics those which point to its biological age, the basis for an identification of the individual.

EXAMINATION, PRESERVATION AND MUMMIFICATION OF THE BODY

During February 23–24, 1998, I received generous permission from the Director General of the Egyptian Museum in Cairo, Dr. Mohammad Saleh, and that of the Director of Scientific Research Dr. Nasry Iskander to examine and photograph the body from KV 55. Before the study I deliberately did not read the detailed paper by Harrison (1966) in order not to be influenced by it, and performed my observations and measurements independently of his. The majority of them were later found to be in agreement. The few which were not will be noted below.

The mummy had been fully skeletonized by the action of time, climatic conditions of the tomb and perhaps also by an inadequately performed mummification process. When found, it was "very badly preserved after being soaked in water and the skull partly crushed by a block which had fallen from the roof" (Maspero 1910, Helck 2001: 26). The skeleton was reconstructed by Derry (1931). Much of the right side of the cranial vault, the lateral wall of the right orbit, sphenoid bone, right maxilla and nasal bones were missing, as shown in Plate XXXVII by Elliot Smith (1912), and these elements were replicated using a copy of the left side (Harrison 1966: 106). Further restorations were performed by Nasry Iskander in 1984 with the aid of X-ray templates (Harris, Hussien 1991).

Nasal bones and nasal cavity are missing. The mastoid processes are partly broken off. The mandible is complete except for the broken crowns of the right canine, the second right incisor and both first incisors. The manubrium sterni is missing. Some vertebrae have defects in their bodies (T7, T9, T11, T12). The sacrum lacks the fifth segment and the left lateral mass of the fourth segment. Both scapulae have partly damaged edges and post mortem perforated supra- and infraspinous fossae. The left humeral head is partly damaged. Of the left hip bone the pubic bone is missing, and the ilium was perforated post mortem by an irregular oval opening (32×19 mm). The posterior end of the iliac crest

FIGURE 2. Skull of KV 55 in right lateral view showing defects and restauration of temporal, frontal and facial regions. Photo E. Strouhal.



was broken off the right hip bone. Both fibulae were broken, but are now mended. The right patella is missing.

Traces of a resinous smear on the cranial base, in the dental intertubercular fissures and on the inner side of the occipital squama are indicative of the mummification process. Due to the damage sustained to the nasal cavity, the removal of the brain via the nose cannot be proved. Several postcranial bones bear traces of resin (e.g. the vertebrae and some joints).

METHODS

Most of the morphological measurements and indices derived them were performed using the method by R. Martin and K. Saller as described in their German language Textbook of Anthropology, 3rd edition, part I (1957) and II (1959), where techniques of their determination are described in detail. Added were procedures by Giles and Elliot (1963), concerning length of the mastoid process (ML) and of the author, concerning its thickness (MT). Some dental features were determined by schemes of Brothwell (1972). To obtaining a more precise value of the ischiopubic index, the ischium height was taken including diameter of the acetabulum, while the pubis length excluding the acetabulum, according to Thieme and Shull (1957). For reconstruction of the stature tables

by Trotter and Gleser (1952) were applied, because they fit best to the proportion of the Egyptians and Nubians (Strouhal, Bareš 1993: 89).

RESULTS

Morphometrics of the skull

The skull is medium robust. Its face is high, wide and symmetrical (*Figure 1*). The cerebral part widens from front to back, being sphenoid from the vertical view (*Figure 4*), very wide and low with prominent parietal eminences in posterior view (*Figure 5*). The glabella is moderately protruding (degree 2–3 of Broca in Martin, Saller 1957), the superciliar arches are medium strong. Under the very prominent anterior nasal spine (degree 4 of Broca in Martin, Saller 1957) is a thin vertical crest bordered by depressions. The eye sockets are of voluminous rounded lozenge form with sharp margins (*Figure 1*). The medial profile line shows a postglabellar depression, after which it recedes with a slightly arched turn. The temporal lines and supramastoid crests are strongly developed. The external occipital protuberance is of medium size (degree 2 of Broca in Martin, Saller 1957), the superior nuchal line is well marked, while the nuchal muscular relief is still only feeble (*Figures 2–3*). Both mastoid processes are voluminous and pneumatized

FIGURE 3. Skull of KV 55 in left lateral view with smaller defects. Photo E. Strouhal.



FIGURE 4. Skull of KV 55 in vertical view showing its sphenoid form. Photo E. Strouhal.



FIGURE 5. Skull of KV 55 in occipital view showing its depressed (platycranic) form with exaggerated breadth. Photo E. Strouhal.

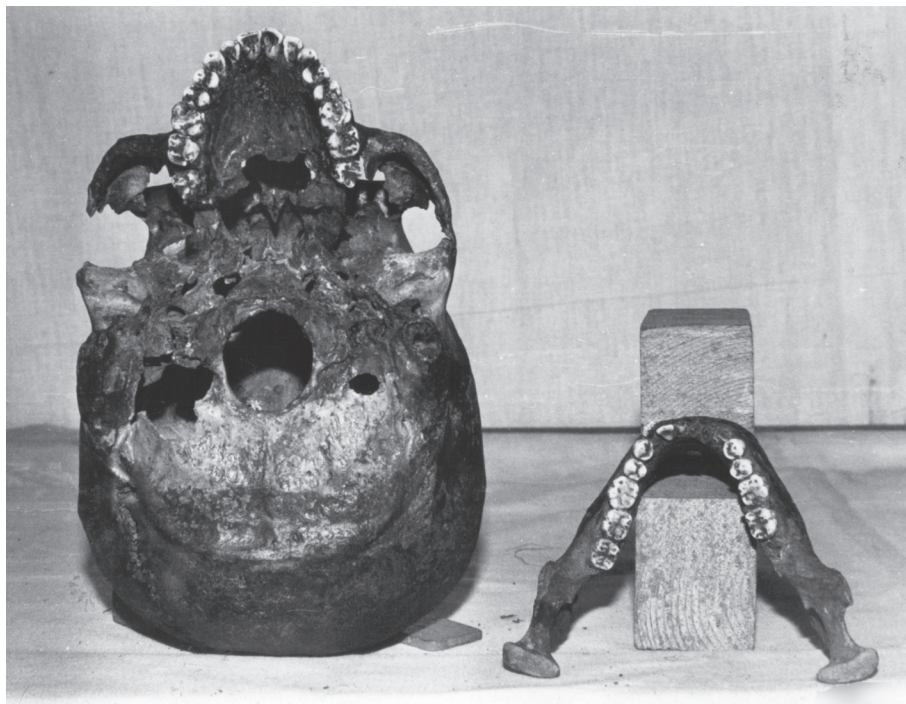


FIGURE 6. Skull of KV 55 in basal view and its mandible in vertical view. Photo E. Strouhal.

(Harrison 1966: plate XXIV, 2), the mastoid notches are medium and wide in size (Figure 6). The palate is wide (44 mm) and deep (about 17 mm), the foramen magnum is oval and wide.

The sphenoccipital synostosis still has an observable line of dense bone which disappears at 18–20 years, at the latest at 25 years of age (Harrison 1966: plate XXIII, 2). All cranial sutures are open from outside, initial fusion can be observed inside the lateral halves of the coronal suture and in short sections of the lambdoid suture. This suggests an age under 30 years.

The mandible is robust, with medium to strong muscular relief and only slight eversion of its rounded angles. The chin is very prominent, with mound-like, broad rounded tubercula mentalia. Both condyles are big and smoothly rounded (Figures 1–3).

All cranial features attest unanimously the male sex of the individual.

If the 33 measurements (Table 1) are compared with the male measurement data of the Ancient Egyptians from the secondary cemetery in the Mastaba of Ptahshepses at Abusir, dating from first millennium BC (Strouhal, Bareš 1993: 152–154), the majority of the values of KV 55 (20) fit into the $\bar{x} \pm s$ (mean \pm standard deviation) interval. Several others, however, cross the limits of the interval.

Thus, the maximum length of the skull is bigger than $\bar{x} + s$, the basis length smaller than $\bar{x} - 2s$, and three breadth measurements are bigger – the minimum frontal breadth more than $\bar{x} + s$, but the maximum breadth and the biauricular breadth as much as $\bar{x} + 3s$.

From the facial measurements, the height of the face is bigger than $\bar{x} + s$, the orbital and nasal heights more than $\bar{x} + 2s$. It applies also, but less, for breadth measurements, as

the bizygomatic, interorbital and maxilloalveolar breadths are bigger than $\bar{x} + s$.

Concerning the mandible, the bicondylar breadth was found to be bigger than $\bar{x} + 2s$ and the lower posterior teeth length bigger even than $\bar{x} + 3s$.

To sum up, in comparison with the chosen "Egyptian male standard", the skull of KV 55 appears longer, extremely broad, possessing higher facial dimensions and a very big dentition.

Harrison's (1966) data are identical or differ by one millimetre, except for heights of the upper face and nose (both 4 mm less than ours) as well as the height of the ascending ramus (6 mm less). The first two are mere approximations due to bone damage, the last one is a methodological difference.

From 27 computed indices only 12 fit into the comparative $\bar{x} \pm s$ variation range of the Abusir Ptahshepses series. This indicates a different cranial build of skull KV 55.

Concerning the indices of the neurocranium, the cranial index is bigger than the $\bar{x} + 2s$ range and falls into the beginning brachycranic category. While the relation between height and length appears as usually orthocranic, the height-breadth index is lower than $\bar{x} - 2s$ range, belongs to the tapeinocranic category. Also the mean height index reflects the relatively low cerebral part of the skull. The maximum breadth measured at euryons surpasses in both the biauricular and bimastoid indices the breadth at the skull basis by $\bar{x} + 2s$. The foramen magnum index shows its slightly shorter shape fitting into interval of $\bar{x} - s$.

Both the facial and upper facial indices fit into the "standards", being mesoprosopoe and mesen. The hypsiconch orbital index is bigger than $\bar{x} + s$. The leptorrhinous nasal index and the transversal naso-facial indices are smaller

TABLE 1. Cranial measurements of skull KV 55. The numbers of Martin and Saller (1957), ML: a projective distance from the horizontal plane through the porion to the tip of the mastoid process according to Giles and Elliot (1963), MT: distance between the bottom of the mastoid notch and the lateral prominence of the mastoid process.

No.	Measurement	Value (mm)
1	Maximum length of the skull	191
5	Basis length	92
7	Length of the foramen magnum	38
8	Maximum breadth of the skull	153
9	Minimum frontal breadth	98
11	Biauricular breadth	127
13.1	Maximum bimastoid breadth	128
16	Breadth of the foramen magnum	31
17	Basion – bregma height	136
ML	Length of the mastoid process	34
MT	Thickness of the mastoid process	14
40	Length of the face	91
45	Bizygomatic breadth	136
47	Height of the face	122
48	Height of the upper face	73
48.1	Height of the alveolar part	19
50	Anterior interorbital breadth	23
51	Orbital breadth	42
52	Orbital height	37
54	Nasal breadth	24
55	Nasal height	54
60	Maxilloalveolar length	52
61	Maxilloalveolar breadth	66
63	Breadth of palate	44
MH	Malar height	23
65	Bicondylar breadth of the mandible	127
66	Bigonial breadth of the mandible	100
68.1	Mandibular length	109
69	Symphyseal height of the mandible	33
69.1	Height of the mandibular body	34
69.3	Thickness of the mandibular body	11
70	Height of the ascending ramus	70
71	Minimum breadth of the ascending ramus	31
79	Mandibular (gonial) angle left	123
80	Mandibular (gonial) angle right	118
80.2	Lower posterior teeth length	49

than $\bar{x}-s$, while the vertical naso-facial index fits into the norm. The brachyuranic maxilloalveolar index is $\bar{x}+2s$ high, while the mesognathous gnathic index and the facial modulus are more than $\bar{x}+s$ high.

All mandibular indices fit well into the accepted "standards", lying in its lower half ($\bar{x}-s$). The mandibular length–breadth index is an exception for its position in the upper half of the norm ($\bar{x}+s$), because of the dominance of the bicondylar breadth over the mandibular length.

Two of the three craniofacial indices reveal different proportions if compared with the norm. The longitudinal index was influenced by short face compared with long skull by $\bar{x}-2s$, the transversal index by smaller bizygomatic breadth compared with the cranial breadth by $\bar{x}-s$. Only the vertical index with a bigger upper facial height

TABLE 2. Cranial indices of skull KV 55. The numbers of Martin, Saller 1957, +: modification of the index.

No.	Index	Value
1	Cranial i. (8:1)	80.1
2	Basion height – length i. (17:1)	71.2
3	Basion height – breadth i. (17:8)	88.9
HK	Mean height (Hrdlička-Kočka i., (17:(1+8):2)	79.1
AB	Biauricular – maximum breadth i. (11:8)	93.4
MB	Bimastoid – maximum breadth i. (13.1:8)	94.1
33	Foramen magnum i. (16:7)	81.6
37	Cranial modulus (1+8+17)/3	160.0
38	Facial i. (Kollmann, 47:45)	89.7
39	Upper facial i. (Kollmann, 48:45)	53.7
40	Jugomandibular i. (66:45)	73.5
FM	Frontomandibular i. (66:9)	102.0
42	Orbital i. (52:51)	88.1
48	Nasal i. (54:55)	44.4
51.1	Transversal naso-facial i. (54:45)	17.6
51.2+	Vertical naso-facial i. (55:48)	74.0
54	Maxilloalveolar i. (61:60)	126.9
60	Gnathic index (40:5)	98.9
61	Facial modulus (40+45+47)/3	116.3
62+	Length-breadth i. of mandible (68.1:65)	85.8
63	Ascending ramus i. (71:70)	49.2
64	Mandibular breadth i. (66:65)	78.7
66	Thickness of mandibular body index	32.4
69	Longitudinal craniofacial i. (40:1)	46.1
70+	Vertical craniofacial i. (48:17)	53.6
71	Transversal craniofacial i. (45:8)	88.9

compared with the cranial height fits into the upper half of the norm.

To sum up: in comparison with the chosen "Egyptian male standard", the skull of KV 55 appears longer, extremely broad, but lower (platycranic), possessing a higher face, orbits and nose, broad jaws as well as a very big dentition.

Harrison (1966: 117, 107) measured also the horizontal circumference of the skull, revealing it to be large as 555 mm, and determined the mean cranial capacity (1,672 ccm), which is also large (megacephalic, aristencephalic). By X-ray he also studied the frontal sinuses, which are large (height of both 38 mm, breadth of left 39 mm, breadth of right 41 mm, Harrison 1966: 108). His cranial index is slightly more brachyranic (81.05) than ours.

On the cranial vault slightly radiating striae parietales can be observed (*Figure 4*). Both occipital condyles are of normal shape, rounded, without any trace of ossification and arthritic changes. In spite of the broken off dorsum sellae, the bottom of the sella turcica appears not to be enlarged. This excludes hypertrophy of the hypophysis. Absence of impressions of digitatae and other signs of increased intracranial pressure by cerebrospinal fluid, can be revealed. This attests to the absence of hydrocephalus.

Dental record

The upper dentition (*Figure 7*) has been preserved completely. All teeth are fully erupted except for the



FIGURE 7. Upper dentition of KV 55. Left: Sharp view of the dentition without the right upper third molar. Right: Less sharp view with the same erupting molar *in situ*. Photo E. Strouhal.

right upper third molar, whose crown reaches only 2 mm above the edges of its alveolus. Tooth attrition is only moderate, revealing in most teeth tiny dots or lines of dentine (beginning stage 3 of Brothwell 1972: 69), while both left upper incisors and both second molars have only slight abrasion of enamel (stage 1), and both third molars are still intact (stage 0).

The lower dentition (Figure 8) shows the postmortem breaking off of the crowns of both first incisors and right second incisor, canine and third molar. Most of the preserved teeth show only tiny dots of dentine (beginning stage 3) except for the left lower canine with slight abrasion of enamel (stage 1), and both second molars and the left third molar (stage 0) are intact.

According to X-ray, the teeth showed no evidence of secondary dentine formation, periodontitis or increased cementum formation, regarded as signs of an older age (Harrison 1966: 109, plates XXIII, 1, XXV, 2). The same author offered the conjecture on the basis of modern European standards, an age 19–20 years, taking into account the consumption of a much coarser Ancient Egyptian diet, even an age of 18–19 years.

Both dental rows are arched in parabolic form and show crowding of the anterior teeth. In basal view, the upper canines are rotated, the left one clockwise, the right one anti-clockwise. The upper second incisors are rotated in a reverse sense: the left one anti-clockwise, the right one clockwise. The left upper first incisor is rotated clockwise with its mesial facet placed to the anterior of the normally placed right one.

The preserved left lower frontal teeth exhibit still greater crowding. The second incisor is erupted behind its neighbours, being hidden from anterior view 3 mm by the caninus and 1 mm by the body of the first incisor. According to the crown torsion of the right first and second incisors in vertical view, they were clockwise rotated and the second one pushed posteriorly. These anomalous teeth positions suggest discrepancy between eruption of big-sized teeth and slower growing alveolar processes of both jaws.



FIGURE 8. Lower dentition of KV 55. Photo E. Strouhal.



FIGURE 9. Sternal ends of both clavicles of KV 55 without epiphyses, showing the deep rhomboid fossa on the right one. Photo E. Strouhal.

A morphological anomaly, additional tubercles of Carabelli, can be observed on the palatal facets of both upper first molars, extending only to two thirds of their height. All upper incisors and the only preserved lower left second incisor are shovel-shaped.

TABLE 3. Measurements of anterior heights of vertebral bodies except for the transversal diameter of the first cervical vertebra. The second body was measured comprising the dens axis (mm).

	Cervical vertebrae	Thoracic vertebrae	Lumbar vertebrae
1	75	16	25
2	39	17	25
3	13	19	25
4	13	18	25
5	12	18	25
6	11	19	–
7	14	20	–
8	–	21	–
9	–	20	–
10	–	21	–
11	–	23	–
12	–	23	–

All teeth have highly protruding cusps without signs of their having been leveled by use. They are completely free of caries and its sequelae. Their alveoli are physiologically shaped and both alveolar processes reveal only the minimum of horizontal retraction (stage 0–1 of Brothwell 1972: 150).

Both mandibular condyles (*Figure 9*) and the mandibular fossae of the temporal bones are smoothly rounded without the slightest trace of degenerative arthritis.

The dental record is consistent with the age at death of 18–22 years.

Features of the postcranial skeleton

Vertebral column

All vertebrae have been preserved. All are free of any, even incipient, pathological change. Their unfinished growth can be attested by the remaining traces of apophyseal growth fissures found in C3–7 and T1–8. They are closed completely in T9–10 and L2–5 and owing to a damaged edge they could not be evaluated in T11–12 and L1. Vertebral growth fissure should be closed before 20–25 years (Schinz *et al.* 1952), more precisely between 20–23 years (McKern, Stewart 1957, Krogman 1962).

All vertebrae show anterior body heights conspicuously smaller than can be expected in an fully adult robust male (*Table 3*). This can be evaluated as consequence of their unfinished growth.

Sacrum

The fissures between the single bodies are still apparent. The fifth segment is missing, most probably by a break after recent fusion (note: sacral bodies fuse in direction from S5 to S1, which means that S5–S4 should be firstly fused in comparison with the cranial ones). On the spinal processes are traces of their coalescence from two halves.

These features should disappear prior to 23 years except for the fissure between S1 and S2 (which can last longer (McKern, Stewart 1957, Krogman 1962).

Sternum

First sternebra is separated, broken off after being in recent fusion with the second one. There are traces of recent union between the 2nd and 3rd sternebra. Joint surfaces for 4th ribs still have transverse fissures. Fusion between the two first sternebrae occurs between 16 and 25 years (Čihák 1987), or more precisely from 19 to 23 years (Harrison 1966: 99). The costal notches are deep but not enlarged, still not spacious as in adult men.

Ribs

Heads and tubercles of ribs are either not fused or bear traces of recent fusion which occurs between 20–25 years (Schinz *et al.* 1952). They should be fused by 24 years (McKern, Stewart 1957, Krogman 1962).

Upper extremity girdle

Concerning the morphoscopic features, all bones are medium robust, except for the still less robust scapulae and humeri, in accordance with the young adult age of the individual. Their muscular relief is not yet prominent. Vertebral borders of both scapulae are not yet fully fused. The superior margins of the scapulae have shallow notches (degree 2 of Olivier 1960). Perforations of the supraspinous and infraspinous fossae are of postmortem origin due to their extreme thinness, in accordance with the young adult age of the individual. No lipping can be found around the glenoid cavity.

Curvature of the clavicles is medium to strong. On the mediocaudal aspect of the clavicle, there is a lengthwise cleft on the right side, called a rhomboid fossa (20×5 mm, 4 mm deep), with sharp edges and a bumpy base. The rhomboid fossa is for the insertion of the costoclavicular ligament. On the opposite left side, a mild depression (9×7 mm, 1 mm deep), smooth on its edge, with a spongiotic base and a small (2 mm deep) pit on lateral side can be observed. These findings suggest, that the individual used his right arm more intensively than the left one already during childhood, exerting stress on the costoclavicular ligament.

At the same time, the sternal epiphyses of both clavicles are not yet fused (*Figure 9–10*). Their fusion between 20 and 25 years of age (Schinz *et al.* 1952), has been later divided into three stages, of which stage I with bumpy surface and as yet not-united epiphysis, is characteristic of an age of 18–20 years (Szilvásky 1978).

Consistent with the young adult age are the humeral features, such as the slightly marked deltoid tuberosity, smoothly rounded medium prominent crest of the greater tubercle and a slight crest of the lesser tubercle of the humerus. The line of separation of the lateral epicondyle is marked only on the left humerus, not on the right one. Another feature indicating a not yet robust skeletal build



FIGURE 10. The bumpy surface of diaphyses on sternal ends of both clavicles of KV 55. Photo E. Strouhal.

is the supratrochlear foramen (left 8×7 , right 8×7 mm). No lipping can be discerned on either humeral joint surfaces.

Also antebrachial bones reveal features of their as yet unfinished young male form. They are only slightly curved, their interosseous margins are medium, the radial tuberosities are smooth and the muscular relief on the ulnae is slight. No lipping is present in the joints. In the ulnar notch of both radii, traces of fusion of their distal epiphyses are still visible. They fuse between the age of 17–19 years (Čihák 1987) or 20–22 years (Schinz *et al.* 1952).

Compared with the values of the Abusir Ptahshepses series (Strouhal, Bareš 1993: 159), all measurements and indices of the humerus, radius and ulna are within the range $\bar{x}-s$, except for the length of the left clavicle and the circumference of both clavicles which are slightly greater than the range $\bar{x}+s$, while the length of the right clavicle and both robusticity indices fall within the range $\bar{x}+s$. Concerning the right-left differences in length, the right humerus is 4 mm longer than the left and the left ulna is by the same value longer than the right one, while no difference was found in the radius. The lower epiphyseal breadth of the humerus and circumference of all the diaphyses is only slightly larger right than left except for the equal value in radius. Robusticity indices are slightly higher on the right side, except for radius, which shows equal values on both sides. Robusticity of the humeral head is, on the other hand, slightly bigger on the left.

Hip bone (os coxae)

The robusticity of the bone and its ischial tuberosity are medium, the pelvic inlet heart-shaped (measuring antero-posteriorly as well as transversally 101 mm according to Harrison 1966: 110), the obturator foramen is ovoid and the iliac crest is medium robust. The greater sciatic notch is open by about 80 degrees (more on the right than the left side), which is an intermediate value between the male and female ones. A clear male pubic angle, prominent pubic tubercle and slightly drawn out phallic crest (together with most of the other features of the skeleton) unanimously attest, however, the male sex.

Concerning the age at death, symphyseal surface of the pubic bone displays a well-preserved relief of protruding



FIGURE 11. Symphyseal surface of the right pubis of KV 55 with well formed relief of slanting ridges and grooves, starting to merge at the posterior edge. Photo E. Strouhal.



FIGURE 12. Close-up of the left iliac crest of KV 55 with fissures after recent fusion. Photo E. Strouhal.

TABLE 4. Measurements and indices of the upper extremity girdle. +: maximum length instead of the total length.

Bone	No.	Measurement	Left	Right
Scapula	1	Morphological breadth (= height)	144	–
	2	Morphological length (= breadth)	97	96
	9	Maximum breadth of the acromion	–	35
	10	Length of the acromion	20	22
	12	Length of the glenoid cavity	36	36
	13	Breadth of the glenoid cavity	25	25
	–	Scapular index (2:1)	67.4	–
	–	Acromial index (10:9)	–	62.8
	–	Length-breadth i. of the glenoid cavity	71.4	71.4
Clavicle	1	Maximum length	154	154
	6	Circumference of the mid-diaphysis	42	43
	–	Robusticity index (6:1)	27.3	27.9
Humerus	1	Maximum length	318	322
	4	Lower epiphyseal breadth	61	60
	7	Minimum circumference of the diaphysis	60	61
	8	Circumference of the head	135	135
	–	Robusticity index (7:1)	18.9	18.9
	–	Robusticity index of the head (8:1)	42.5	41.9
Radius	1	Maximum length	242	242
	3	Minimum circumference	41	41
	–	Robusticity index (3:1) +	16.9	16.9
Ulna	1	Maximum length	259	255
	3	Minimum circumference	34	36
	–	Robusticity index (3:1) +	13.1	14.1

TABLE 5. Measurements and indices of the hip bones (ossa coxae). Ischium height including acetabulum, pubis length without acetabulum. (...): without apophysis of the ischial tuberosity.

No.	Measurement	Left	Middle	Right
1	Pelvic height	(201)		207
12	Maximum pelvic breadth	152		150
15	Height of the ischium	(94)		99
17	Length of the pubis	–		61
18	Height of the symphysis	–		39
22	Maximum diameter of the acetabulum	53		53
33	Subpubic angle		70	
–	Breadth – height index of the pelvis (12:1)	–		72.5
–	Ischio-pubic index (17:15)	–		61.6

oblique crests divided by furrows which start to merge only slightly at the posterior edge (*Figure 11*). This picture fits between phases 1 and 2 of Todd (1920), appearing between 19–20 years of age according to Briggs (1958), 20–21 years according to Harrison (1966: 110) or 18.9 ± 2.3 years (in 95% 15–23 years) of phase I by Suchey, Katz (1986).

Traces of apophyseal union can be found along the edge of the iliac crests except for 100 mm from the posterior superior iliac spine on left side and 90 mm on right side, where they are perhaps covered by modern restoration coating (*Figure 12*). The inferior ramus of the pubis and ramus of the ischium still bear traces of the process of

joining. The right inferior ramus of the pubis is covered by its apophysis, fused only lightly, from the edge of the symphyseal surface about 23 mm caudally; on the left side this part is missing. In the continuing part of both inferior rami of the pubis down to the ischial tuberosities, the apophyses have been broken off and the bumpy surface of the bone exposed (*Figure 13*). Also the surface of both ischial tuberosities is still bumpy, without apophyses (*Figure 14*).

Compared with the Abusir Ptahshepses series (Strouhal, Bareš 1993: 159) all metric data (*Table 5*) are in harmony with the male sex of the individual and belong in the range of

TABLE 6. Measurements and indices of the lower extremity bones.

Bone	No.	Measurement	Left	Right
Femur	1	Maximum length	458	456
	2	Total length	454	454
	6	Sagittal diameter of the mid-diaphysis	29	29
	7	Transversal diameter of the mid-diaphysis	25	25
	9	Upper transversal diameter of the diaphysis	32	32
	10	Upper sagittal diameter of the diaphysis	25	25
	20	Circumference of the head	143	144
	–	Robusticity index (6+7: 2)	11.9	11.8
	–	I. of mid-diaphysis section (pilastricus, 6:7)	116.0	116.0
–	I. of upper diaphys.section (platymericus, 10:9)	78.1	78.1	
Tibia	1	Total length	369	371
	8a	Maximum diameter at nutrient foramen	38	37
	9a	Transversal diameter at nutrient foramen	25	25
	10b	Minimum circumference	79	78
	–	Cnemic index (9a:8a)	65.8	67.6
	–	Robusticity index (10b:1)	21.4	21.0
Fibula	1	Maximum length	355	357
	4a	Minimum circumference	34	35
	–	Robusticity index (4a:1)	9.6	9.8
Patella	1	Length	40	40
Talus	1	Length	56	55
Calcaneus	1	Length	79	78

TABLE 7. Reconstruction of the stature according to tables for Afroamericans (Trotter, Gleser 1952).

Bone	Length (mm)	Stature estimation (cm)	
		by single bones	by the upper and lower limb bones and sum
Humerus	320	166.3	
Radius	242	164.3	164.5
Ulna	257	163.0	
Femur	457	166.8	
Tibia	370	167.0	165.8
Fibula	356	163.6	
Humerus + Femur		166.6	
Radius + Ulna		163.7	
Tibia + Fibula		165.3	
Mean stature			165.15

\bar{x} -s, except for the height of the ischium being smaller than this range (\bar{x} -2 s). This reflects still smaller hip bones because of the as yet unfinished growth and apophyseal union. The ischio-pubic index fits decisively into the male sex.

Lower extremity bones

All bones are medium robust to robust. The femur has only a medium strong pilaster (stage 2 by Martin, Saller 1957) and a feeble gluteal tuberosity, both in harmony with the young adult age of the individual. No third trochanter or subtrochanteric fossa are present. Recent fusion of

apophyses has been revealed by sulci around both heads.

Of the tibia, the soleal line is still partly grooved, as occurs usually in childhood, with the formation of a crest just beginning, more distinct on the right side (*Figure 15*). On the contrary, the fibular grooving is still only slight. Remnants after epiphyseal junction at the distal end can be presumed, but could not be attested, being covered by a modern consolidating matter. All lower extremity joints are free of pathological changes. Of the small foot bones, only the calcaneus displays the beginnings of tiny osteophytes in the insertion of the Achilles tendon.

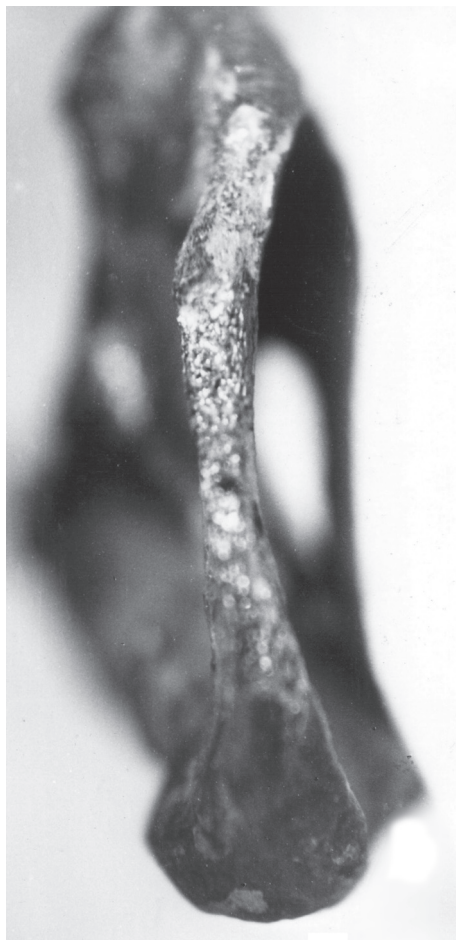


FIGURE 13. Inferior ramus of the right pubic bone of KV 55 with exposed bumpy bone without the apophysis. Photo E. Strouhal.



FIGURE 15. Both tibiae of KV 55 with the partly grooved soleal lines. Photo E. Strouhal.

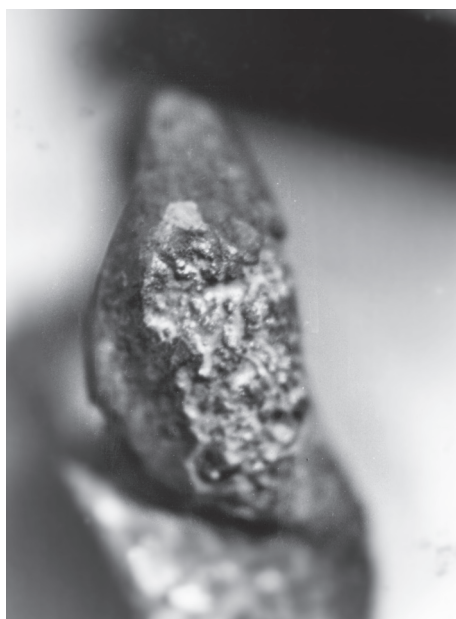


FIGURE 14. The right ischial tuberosity of KV 55 partly covered by apophysis, which has been broken off in the centre, exposing the bumpy surface. Photo E. Strouhal.

Compared with the Abusir Ptahshepses series (Strouhal, Bareš 1993: 160), the metric features and indices of lower extremity bones (*Table 6*) belong in the male range of $\bar{x}+s$ except for the maximum diameter at level of nutrient foramen of the tibiae, which is slightly greater than this range. However, the femoral transversal diameter of the mid-diaphysis, the circumference of the head and the robusticity index, the cnemial index and the lengths of patellae and tali fit into the range of $\bar{x}-s$.

Harrison's (1966) measurements of the maximum length of the femur are shorter (by 5 mm left and 3 mm right), of total the lengths of the tibiae longer (left by 3 mm, right by 4 mm). These reflect deviations in measuring techniques.

Reconstruction of the living stature

Because Harrison (1966) reconstructed the stature of the individual from KV 55 by other equations (see below), we used the simple tables for Afroamericans by Trotter and Gleser (1952), which were found to fit best the proportions of Ancient Egyptians and Nubians (Strouhal, Bareš 1993: 89).

Maximum lengths of single bones are the means of both sides. In view of the young age of the individual,

no reduction of the reconstructed stature, necessary for individuals over 30 years of age, was applied.

The estimated stature judged by single bones shows a relatively narrow range of 163 cm to 167 cm. At the same time, reconstructed stature according to the upper extremity bones is 1.3 cm lower than the stature reconstructed by the lower extremity bones. If we compare the stature value generated by the proximal bones of both extremities, they are bigger than the stature values reconstructed by distal bones – 2.9 cm by upper and 1.3 cm by lower extremities. The resulting stature 165.2 cm is almost identical with the male mean stature 165.3 cm of the Abusir Ptahshepses series (Strouhal, Bareš 1993: 162).

In contrast to our results, Harrison (1966: 110–111, 118–119) estimated the stature according to equations for American White males (Trotter, Gleser 1952, 1958), obtaining means as high as 170.5 and 171.1 cm or by the general formula for males (Dupertius, Hadden 1951), with a still bigger mean of 171.3 cm.

It should be added that Hussien and Harris (1988), measuring the dismantled skeleton joined together directly, determined its length as 164.4 cm, which is quite close to our indirect result.

DISCUSSION

Concerning the sex determination of the mummy when found, the two surgeons who visited the Valley of the Kings in 1907, examined the pelvis, specifying its female sex. The mummy was thus originally supposed to be the body of Queen Tiye. Elliot Smith, however, soon discerned its male sex, in spite of the fact that it "was much more slenderly in build and more effeminate than that of Amenophis III". These features were, however, caused by its young age. Misled by the name of Khouniatonu (then the reading of the name Akhenaten), Elliot Smith attributed the skeletal remains to this king (Davis 1910: 3, Elliot Smith 1910: XXIII–XXIV, Elliot Smith 1912: 51–56). The male sex was accepted also by all succeeding researchers.

Concerning the individual age at death of the male, Elliot Smith (1912) determined it to be 25–26 years, allowing for a range of ± 2 –3 years, arguing that "it is highly improbable that he could have attained thirty years if he had been normal". However, he attributed to the individual the diagnosis of hydrocephalus, which could have caused a delay of ossification (Elliot Smith 1910).

Weigall (1922) tried to show from Egyptological arguments that Akhenaten was not more than 30 years old at death. By this hypothesis he wanted to reconcile a perfectly genuine block from the Fitzwilliam Museum Cambridge (U.K.) showing a celebration of Akhenaten's *heb-sed*, which took place as a rule 30 years after a king succeeded to the throne, by supposition that Akhenaten acceded immediately on his birth! If so, his age came closer to the upper limit of Elliot Smith's age determination. He dared to argue that the KV 55 body's "facial structure

corresponds to the portraits of Akhenaten and his physical characteristics are similar to those of Akhenaten's father and grandfathers".

D. E. Derry (1931) restored the originally broken face of the KV 55 skull and re-examined the skeleton, overturning the hydrocephalus hypothesis. As a result of his and Girgis Sidhom's study on epiphyseal union of the upper limb of the living Egyptians compared with European standards, Egyptians showed 1–2 year earlier closure than Europeans. According to these results, the KV 55 skeleton was a man not more than 23 years old. Derry admitted the unusual shape of the skull and its extraordinary width, which can, although rarely, occur in Ancient Egyptians, as in the case of Queen Hetepheres (Dynasty 4) or Tutankhamun. The latter accords with the results of Engelbach (1931), who suggested that traces of erased inscriptions with cartouches on the gold plates and coffin containing the KV 55 skeleton belonged not to Akhenaten, but to Smenkhkare, Tutankhamun's older brother, and probable son of Akhenaten and Nefertiti or by another wife, conceivably a concubine. The close relation of Smenkhkare and Tutankhamun was demonstrated by the close values of their six basic cranial measurements (Derry 1931: 119).

C. Aldred and A. T. Sandison (1962) summarized certain medical studies of possible disease suffered by Akhenaten according to his features as depicted in his monuments, comparing them with the published data and photos of the remains from tomb KV 55. They tried to reconcile them on the basis of a pituitary lesion, probably an adenoma, causing hypogonadism. The age at death of the mummy became 'blurred' by this pathology. The authors maintained the idea that the KV 55 skeleton was of Akhenaten. Having decided this, they had then to conjecture about Akhenaten's inability to engender six daughters, whose "only possible sire would be King Amenophis III".

The fundamental breakthrough came when a detailed anatomical examination of the KV 55 skeleton, performed not only by the naked eye, but also by X-rays, was carried out by R. G. Harrison in the Egyptian Museum and the Qasr el-Aini Hospital of Cairo University in Giza in 1963. He confirmed its male sex and determined the age to be lower (20 years, with a possible range from 17 up to 25 years). He pointed out the absence of any disease which could have caused a delay of epi- and apophyseal union. By studying the reconstructed proportions of the body, he admitted, however, a minimal effect of hypogonadism. By reconstruction of the living face using the method of Kollmann and Büchly (1954) and by comparison with Tutankhamun's iconography, he demonstrated the similarity of the KV 55 face with the face of Tutankhamun, finding at the same time no resemblance to the somewhat peculiar features of Akhenaten's face in depictions.

By identifying the same blood groups A2 and MN of the body KV 55 (Smenkhkare) and Tutankhamun, their kinship (as brothers) was supported later by R. C. Connolly (1969) and Harrison and Connolly (1969), and inserted into their serological pedigree (Connolly *et al.* 1976). Physiognomic

similarity of these individuals was confirmed by the same authors (Connolly *et al.* 1976). Dimensions of the frontal sinuses and their sinus–transversal–cranial index were found to be within the male range and decidedly lower than in acromegalic men, as Akhenaten was supposed to be (Costa 1978).

Later C. N. Reeves (1981: 53–54) raised the question on the very identity of the body from KV 55, in spite of Weigall's argument that the bones examined by Elliot Smith were those from the tomb. According to Reeves "from the archaeological and first-hand medical information which has survived, it seems highly probably that the body was that of a woman, and not intended for the coffin in which it was eventually discovered".

The same author later rejected Engelbach's analysis of the texts on the coffin as being for Smenkhkare, believing that "the coffin originally prepared for Akhenaten's secondary wife Kiya...had...been altered to contain the body of Akhenaten himself although the cartouches were excised in antiquity, the texts in their altered form clearly relate to this king". The presence of four Akhenaten's magic bricks in the tomb and erasing the cartouches of the coffin *in situ* "is a clear indication that those who desecrated the coffin believed it to contain the body of Akhenaten" (Reeves 1982: 63–64). He also quoted the representation of the second Amarna princess on boundary stela K dating to Akhenaten's year 5 (Davies 1908: 24), which implied that Akhenaten was by the second or third year of his reign mature enough to procreate "...and thus not less than 30 years at...his death....(but) between 35 and 40". Referring to the criticized low estimation of the ages of the royal mummies (Harris, Wentz 1980), he doubted the age of the KV 55 body which "may...be several years older than has hitherto been assumed" and "... the evidence...seems...to favour the view that CG 61076 is the body of Akhenaten" (Reeves 1982: 65–66).

Following this renewed tendency to return to an identification of KV 55 body as Akhenaten's, F. Hussien and J. E. Harris (1988), allegedly according to wear of the teeth and periodontal recession as well as radiographs of the bones, concluded "that the skeleton (KV 55) was more than 35 years" old.

By an X-ray examination of the KV 55 skull in 1983 and its comparison with the skulls of the Late Eighteenth Dynasty kings in the Egyptian Museum in Cairo, using cluster analysis, the morphological similarity of the skull of KV 55 body and Tutankhamun were reinforced (Ingals *et al.* 1988).

By re-analysing X-rays of all Eighteenth Dynasty royal mummies, Harris and Hussien (1991) came once more to the conclusion by cephalometrics and cluster analyses "that the royal mummies Tutankhamun and Smenkhkare (= KV 55) are most similar". In the same article Fawzia Hussien "demonstrated that this mummy/skeleton (= KV 55) was that of a slight build male of about 35 years of age".

Analysing the presence of objects with cartouches of Nefernefruaten/Smenkhkare in the Tomb KV 55, A.

Dodson (1992) adhered to the opinion that items of burial equipment of Kiya in that tomb were altered for the "young king" Smenkhkare, the son of Akhenaten, who could have been his co-regent.

In a review of the KV 55 problem C. N. Reeves returned to the significance of the magic bricks inscribed with the name of Akhenaten and revived certain arguments of Weigall (1922: 198), who believed that the individual from KV 55 "had the physical characteristics of the portraits of Akhenaten" and "it was that of a man of Akhenaten's age as deduced from the monuments...". He concluded that "...low estimates... for the corpse's age at death, ranging between 20–25/26, ...seem to conflict with the archaeological analysis..." and "the(ir) accuracy... has to be proven. Until it is, Akhenaten, on balance, is who our mummy must be" (Reeves, Wilkinson 1996: 120–121).

M. Eaton-Krauss (2001) in her entry on Akhenaten in *The Oxford Encyclopedia of Ancient Egypt* wrote that according to the results of Martin's (1974, 1989) re-investigation of his royal tomb, that it "provides an unequivocal evidence for the thoroughness with which Akhenaten's monuments were attacked, making it highly unlikely that his mummy survived".

At the end of a short survey on the body from KV 55 Helck in a posthumous book (2001: 26–28) expressed his opinion that "from sole anatomical facts unambiguous identification of the corpse cannot be obtained, only by detailed investigation of the coffin and its inscriptions...". A concise view on the history of the KV 55 mummy problem was presented by R. Germer, who concluded that the male died in the age of 18 to 23 years, maximally 25 years (Germer 2001).

The long expected results of the international "The King Tutankhamun Family Project" based on the analysis of DNA microsatellite markers, included also the skeletal remains of the man from Tomb KV 55, who was identified anew as Akhenaten. This was announced by the simple statement that "...our new computed tomography investigation (of KV 55) revealed that he lived to be much older" (Hawass *et al.* 2010: 640, note b), as much as to 35–45 years (Hawass *et al.* 2010: Table 1). No factual proofs for such a startling change has been included in the printed report. If the alleged X-ray or CT features showed a substantially higher age, the proofs of it should have been submitted for evaluation by professionals. Even then, the arguments by classic morphological ageing features should not be overlooked. As a result of this substantial age change, the vacant place in Tutankhamun's pedigree left for his father was simply filled up by the only existing royal male body of the time, while his elder brother Smenkhkare completely disappeared from the same pedigree (Hawass *et al.* 2010: 641).

No traces of pathologies attributed to Akhenaten according to his iconographic features were found in the KV 55 skeleton (Hawass *et al.* 2010: 641–642). Malformations and pathologies revealed by computed tomography (Hawass *et al.* 2010: 645) do not overturn this argument. The finding of a cleft palate cannot be proven, because the posterior

part of the hard palate was secondarily broken off (see our Figure 7). Scoliosis, if present, was only slight. Osteoma in the maxillary sinus could be present, even if it were not apparent on the standard radiograph (Harrison 1966: Plate XXIV, 2). "Femoral osseous collapse, or bone fibroma" are, without explanations, mysterious diagnoses.

After checking the DNA analyses reported by Hawass *et al.* (2010), a noted Czech specialist in molecular genetics concluded that the agreement of 50 % of genes suggesting kinship of first degree cannot prefer either a father-son relation or a brother-brother one (M. Kuklík, personal communication, June 2011).

CONCLUSIONS

Our detailed re-examination of the unambiguous male skeleton from Tomb KV 55 proved decisively by a long list of biological developmental features his age at death to be in the range of 19–22 years, which fully agrees with the results of the previous determination by Harrison (1966). The complete absence of age-dependent pathological changes strengthens the reality of his young adult age. He did not possess the slightest dental pathology and not even the onset of degenerative changes in his spine and joints. Both would have been significantly advanced, if his age were 35–45 years. The peculiar platycranic form of his neurocranium cannot be attributed to any known pathological change or artificial deformation. It is an individual genetic feature which the man from KV 55 shared with Tutankhamun, contributing to other signs of their close relationship. All other morphometric data of the skeleton fit into the range of the chosen Egyptian sample or close to it. In view of the Egyptologically proven minimum of a 17 years long reign for Akhenaten, we utterly exclude the possibility that he could have been in the first year of his reign at only 2–5 years old, while his brother Smenkhkare, being 19–22 years old, could easily have reigned for 3 or more years.

In the remarkable five-generation pedigree of Tutankhamun (Hawass *et al.* 2010: 641), the place of Akhenaten should remain vacant (perhaps for ever), and alongside Tutankhamun, his elder brother Smenkhkare should be inserted.

ACKNOWLEDGEMENTS

I am deeply indebted to Professor Geoffrey T. Martin and Dr. Corinne Duhig for the correction of my English.

REFERENCES

ALDRED C., SANDISON A. T., 1962: The Pharaoh Akhenaten. A problem in Egyptology and pathology. *Bulletin of the History of Medicine* 36, 4: 293–316.
AYRTON E. R., 1910: The excavation of the Tomb of Queen Tiye, 1907. In: T. M. Davis (Ed.): *The Tomb of Queen Tiye*. Pp. 7–10. Constable and Co., London.

BRIGGS L. C., 1958: *Initiation à l'anthropologie de squelette*. Ministère de l'Algérie, Algiers.
BROTHWELL D. R., 1972: *Digging up Bones*. Second edition. British Museum of Natural History, London.
ČIHÁK R., 1987: *Anatomie I*. Avicenum, Prague.
CONNOLLY R. C., 1969: Microdetermination of blood group substances in ancient human tissue. *Nature* 224: 325.
CONNOLLY R. C., HARRISON R. G., AHMED S., 1976: Serological evidence for the parentage of Tutankhamun and Smenkhkare. *Journal of Egyptian Archaeology* 62: 184–186.
COSTA P., 1978: The frontal sinuses of the remains purported to be Akhenaten. *Journal of Egyptian Archaeology* 64: 76–79.
DAVIES N. de G., 1908: *The Rock Tombs of El Amarna V*. Egypt Exploration Fund, London, pp. 24 ff.
DAVIS T. M., 1910: The finding of the Tomb of Queen Tiye. In: T. M. Davis (Ed.): *The Tomb of Queen Tiye*. Pp. 1–5. Constable and Co., London.
DERRY D. E., 1931: Note on the skeleton hitherto believed to be that of King Akhenaten. *Annals du Service des Antiquités de l'Égypte* 31: 115–119.
DODSON A., 1992: *KV 55 and the end of the reign of Akhenaten*. In: Sesto Congresso Internazionale di Egittologia, Atti, vol. I. Pp. 135–138. Torino.
DUPERTIUS C. W., HADDEN J. A., 1951: On the reconstruction of stature from long bones. *Amer. J. Phys. Anthropol.* 9: 15–53.
EATON-KRAUSS M., 2001: Akhenaten. In: D. B. Redford (Ed.): *The Oxford Encyclopedia of Ancient Egypt*. Pp. 48–51. Oxford University Press, Oxford – New York.
ELLIOT SMITH G., 1910: A note on the estimate of the age attained by the person whose skeleton was found in the tomb. In: T. M. Davis (Ed.): *The Tomb of Queen Tiye*. Pp. 23–24. Constable and Co., London.
ELLIOT SMITH G., 1912: *The Royal Mummies. Catalogue Général des Antiquités Égyptiennes du Musée du Caire* Nos. 61051–61100. Reprint G. Duckworth and Co. Ltd. 2000, London.
ENGELBACH R., 1931: The so-called coffin of Akhenaten. *Annals du Service des Antiquités de l'Égypte* 31: 98–114.
GERMER R., 2001: Die Mumie aus dem Sarg in "KV 55". In: A. Grimm, S. Schoske, (Eds.): *Das Geheimnis des goldenes Sarges. Echnaton und das Ende der Amarnazeit*. Pp. 58–61. München.
GILES E., ELLIOT O., 1963: Determination by discriminant function analysis of crania. *Amer. J. Phys. Anthropol.* 21: 53–68.
HARRIS J. E., HUSSEIN F., 1991: The identification of the Eighteen Dynasty Royal Mummies. A Biological Perspective. *Int. J. Osteoarchaeol.* 1, 3: 235–239.
HARRIS J. E., WENTE, E. F., 1980: *An X-Ray Atlas of the Royal Mummies*. The University of Chicago Press, Chicago and London.
HARRISON R. G., 1966: An anatomical examination of the Pharaonic remains purported to be Akhenaten. *Journal of Egyptian Archaeology* 52: 95–119.
HARRISON R. G., CONNOLLY R. C., 1969: Kinship of Smenkhkare and Tutankhamun demonstrated serologically. *Nature* 224, 325–326.
HAWASS Z., GADY Z., ISMAIL S., KHAIRAT R., FATHALLAH., HASAN N., AHMED A., ELLEITHY H., BALL M., GABALLAH F., WASEF S., FATEEN M., AMER H., GOSTNER P., SELIM A., ZINK A., PUSCH C. M., 2010: Ancestry and pathology in King Tutankhamun's family. *Journal of the American Medical Association* 303, 7: 638–647.
HELCK W., 2001: *Das Grab Nr. 55 im Königsgräbertal*. Sonderschrift, Deutsches Archaeol. Institut Abt. Kairo. Ph. von Zabern, Mainz. Pp. 26–28.

- HUSSIEN F., HARRIS J. E., 1988: *The skeletal remains from Tomb no. 55*. In: Fifth International Congress of Egyptology, Cairo 1988, Abstracts of Papers. Cairo, International Association of Egyptologists, p.140.
- INGALS B. K., HARRIS J. E., HUSSIEN F., EL-NAWAYY I., ISKANDER N., 1988: *The skull from Tomb no. 55*, Luxor. In: Fifth International Congress of Egyptology, Cairo 1988, Abstracts of Papers. Cairo, International Association of Egyptologists, p. 142.
- SUCHEY J., KATZ D. M., 1986: Age determination of the male pubis. *Amer. J. Phys. Anthropol.* 69: 427–435.
- KOLLMANN J., BÜCHLY W., 1954: *The Anatomy of the Eye and Orbit*. London.
- KROGMAN W. M., 1962: *The Human Skeleton in Forensic Medicine*. Charles C. Thomas, Springfield.
- MANNICHE L., 2010: *The Akhenaten Colossi of Karnak*. The American University in Cairo Press, Cairo and New York.
- MARTIN G. T., 1974: *The Royal Tomb at El-'Amarna*. Vol. 1: The Objects, Egypt Exploration Society, London.
- MARTIN G. T., 1989: *The Royal Tomb at El-'Amarna*. Vol. 2: The Reliefs, Inscriptions and Architecture. Egypt Exploration Society, London.
- MARTIN R., SALLER K., 1957: *Lehrbuch der Anthropologie in systematischer Darstellung*. 3. Auflage, Band I. Stuttgart, G. Fischer.
- MARTIN R., SALLER K., 1959: *Lehrbuch der Anthropologie in systematischer Darstellung*. 3. Auflage, Band II. Stuttgart, G. Fischer.
- MASPERO G., 1910: Sketch of Queen Tiyi's Life. In: T. M. Davis (Ed.): *The Tomb of Queen Tiyi*. Pp. 13–21. Constable and Co., London.
- McKERN T. W., STEWART T. D. 1957: Skeletal age changes in young American males, analysed from the standpoint of identification. *Headquarter QM Res. and Dev. Command.*, Tech. Rep. EP-45, Natick, Massachussets.
- OLIVIER G., 1960: *Pratique anthropologique*. Vigot Frères, Paris.
- REEVES C. N., 1981: A reappraisal of Tomb 55 in the Valley of the Kings. *Journal of Egyptian Archaeology* 67: 48–55.
- REEVES C. N., 1982: Akhenaten after all? *Göttingen Miszellen* 54: 61–71.
- REEVES C. N., WILKINSON R. H., 1996: *The Complete Valley of the Kings*. The American University in Cairo Press, Cairo.
- SCHINZ H., BAENSCH W., FRIEDL E., UEHLINGER E., 1952: *Ossifikationstabellen. Lehrbuch der Roentgendiagnostik*, 5. Auflage. Stuttgart, G. Thieme.
- STROUHAL E., BAREŠ L., 1993: *Secondary Cemetery in the Mastaba of Ptahshepses at Abusir*. Charles University, Czechoslovak Institute of Egyptology, Prague.
- SZILVÁSSY J., 1978: Eine Methode zur Altersbestimmung mit Hilfe der sternalen Gelenkflächen der Schlüsselbeine. *Mitteil. Anthropol. Gesellsch. (Wien)* 108: 166–168.
- THIEME E. P., SHULL W. J., 1957: Sex determination from the skeleton. *Human Biology* 29: 242–273.
- TODD T., 1920: Age change in the pubic bone I. The male white pubis. *Amer. J. Phys. Anthropol.* 3: 285–334.
- TROTTER M., GLESER G. C., 1952: Estimation of stature from long bones of American Whites and Negroes. *Amer. J. Phys. Anthropol.* 10: 463–514.
- TROTTER M., GLESER G. C., 1958: A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. *Amer. J. Phys. Anthropol.* 16: 79–123.
- WEIGALLA., 1922: The mummy of Akhenaton. *Journal of Egyptian Archaeology* 8: 193–200.
- ZINK A., HAWASS Z., GAD Y. Z., ISMAIL S., GOSTNER P., SELIM A., PUSCH C. M., 2010: *Genetic and palaeopathological investigation of King Tutankhamun's family*. Plenary Lecture. 18th European Meeting of the Paleopathology Association, Program and Abstracts. Vienna August 2010, p. 251.

Eugen Strouhal
 Charles University Prague
 First Medical Faculty
 Institute of the History of Medicine and
 Foreign Languages
 U nemocnice 4, 121 08 Prague 2
 Czech Republic
 E-mail: eugen.strouhal@lf1.cuni.cz