

Supplementary note 1 – Catalog of the studied individuals with morphological descriptions

Each individual in the present study is described below. Age estimation is primarily based on dental development and eruption (AlQahtani et al. 2010). When all permanent teeth have erupted, tooth wear and cranial suture closure are used, when possible, to distinguish between young (20–35 years), middle (35–50 years), and old adult (50+ years) age stages. Sex estimation is not possible for the juvenile individuals, but for the adults, it is based on sexual dimorphic features of the exposed cranium and mandible observed macroscopically or via CT scanning. In many cases, however, it is not possible to provide a confident assessment of biological sex.

Predynastic

M19 - middle-aged adult, male, 3489–3108 cal. BCE

The individual consists of a partially skeletonized head with small amounts of textile remains adhering to the left parietal region, displaying dark tones. Only a few fragments of mummified tissue persist on the frontal, parietal, and left temporal bones. The cranial sutures are partially closed. All teeth have erupted, without much wear on the third molars. However, the crowns of the anterior teeth are fractured, which could be a post-mortem feature associated with the “Opening of the Mouth” funerary ritual. Additionally, some of the posterior dentition was lost ante-mortem. CT scanning reveals the presence of embalming material, pooled within the right side of the skull. This indicates that the individual lay on its right side. The ethmoid is fractured, and the brain was removed.

The textile and skin samples for radiocarbon dating and lipid residue analysis were taken from the posterior of the cranium.

Old Kingdom

M27 - middle-aged adult, probable male, 2464–2298 cal. BCE

This consists of a partially skeletonized cranium and disarticulated mandible. The upper portion of the head is wrapped in compact, rigid bandages that adhere firmly to the underlying mummified tissues. Residual mummified tissues are present on the upper face and within the orbits, where bandages and soft tissues are still preserved. All permanent teeth have erupted, and dental wear, carious lesions, and alveolar abscesses are observed. There are also signs of arthropathy on the mandibular condyles. CT scanning reveals the presence of the brain and the intact ethmoid. Textiles were collected from the forehead and cheek bone area for radiocarbon dating and lipid residue analysis.

Middle Kingdom

M13 - adult, male, 1952–1769 cal. BCE

This individual consists of a mummified cranium, mandible, and several cervical vertebrae, bearing traces of textile fibers tightly adhering to the facial and cranial surfaces. Both the bandages and the mummified soft tissues are a dark brown to black coloration, and they appear rigid, compact, and heavily impregnated with shiny black embalming substances. The skin is fragile and fissured, and similar dark material is also present within the neck region, where the cervical vertebrae display arthropathy. The oral cavity is visible from below, and an additional exogenous material is present over the supraorbital areas. From the CT scan, we can observe that all permanent teeth have erupted, and extensive dental wear and carious lesions are noted. CT scanning also reveals that the ethmoid is fractured, and the brain was removed.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the left side of the cranium. A loose bone fragment was also collected, but it is unclear from which part of the cranium it originates.

M59 - young adult, probable female, 2026–1883 cal. BCE

This individual consists of a nearly completely skeletonized cranium without the mandible, with the cranial vault bones disarticulated. Small remnants of mummified soft tissue and dark hair including a braided lock adhere to several cranial fragments. Five unworn maxillary teeth remain in situ, with the others lost post-mortem. Additional loose fragments of bone, hair, and sediment are present.

Because there are no textiles, hair was collected for radiocarbon dating and lipid residue analysis. To ensure that the integrity of the braids remained intact, it was collected only from loose hair.

Third Intermediate Period

M18 - older child or young adolescent, sex indeterminate, 806–775 cal. BCE

This individual consists of a partially skeletonized cranium and articulated mandible without a neck, with textile elements preserved only on the face and left side of the head. These layers are tightly compacted, incorporating fine, dark, and locally glossy sediment. Only small remnants of mummified soft tissue and part of the left ear remain, while the mandible and maxilla are fully visible and retain their permanent teeth. The first and second molars are present, but not very worn, and the spheno-occipital synchondrosis is unfused, which also suggests an older child or young adolescent. CT scanning shows that the ethmoid is fractured and the brain was removed. For radiocarbon dating and lipid residue analysis, textiles were sampled from behind the left ear. A loose bone fragment was also collected, but it is unclear where it originates from.

M30 - adult, male, 808–779 cal. BCE

This individual consists of a mummified cranium and articulated mandible without a neck, partially wrapped in bandages. The face is partly skeletonized, with bandages and residual soft tissues preserved in the orbits and nasal packing still in place, and the mouth is slightly open and filled with bandages. All permanent teeth have erupted (shown by CT scanning), the anterior teeth are chipped and fractured (again, perhaps due to a postmortem funerary rite), and some dental wear is observed. Amorphous material consistent with dehydrated brain tissue is visible within the cranial cavity through the foramen magnum, and this is confirmed by CT scanning. CT scanning also shows that the ethmoid is not fractured, and no attempt was made to remove the brain. For radiocarbon dating and lipid residue analysis, textiles were collected from the left side of the mandible, the base of the back of the neck, and the forehead. Multiple sampling locations were required to ensure that there was enough for analysis.

Third Intermediate/Late Period

M4 - middle-aged adult, probable female, 806–593 cal. BCE

This individual consists of a partially skeletonized cranium, articulated mandible and cervical vertebrae partially covered by circular and oblique layers of bandages. Exposed areas, particularly on the left side, show the underlying bone, partially preserved nasal and oral tissues, and both ears. The neck lacks most wrappings and displays a longitudinal ancient incision, with articulated cervical vertebrae showing glossy black embalming material within the vertebral canal. The teeth are visible through CT scanning. All the permanent teeth have erupted, and there is extensive occlusal wear. CT scanning also reveals the ethmoid was fractured and the brain was removed and replaced with embalming material.

For radiocarbon dating, textiles were sampled from the base of the posterior of the crania. For lipid residue analysis, a loose bone fragment was also collected, but it is unclear where it originates from.

M16 - young adult, male, 755–489 cal. BCE

This individual consists of a partially skeletonized cranium, articulated mandible, and cervical vertebrae, largely devoid of wrappings, except for a few flexible brown bandages at the neck. The head exhibits brown, black (locally glossy), and reddish hues, with mummified facial and nuchal tissues preserved but fissured. The cranial vault is partially exposed, and two healed depression fractures are visible on the frontal bone. The orbits contain bandages arranged to resemble eyes, including a painted pupil on the right. The nasal cavity also contains packing material. The neck is well preserved, and an articulated vertebra is visible, with no embalming material detected in the vertebral canal. The permanent teeth were observed primarily via CT scanning; all have erupted, and there is no observable occlusal wear. CT scanning also reveals that the ethmoid was fractured and the brain was removed.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the left side of the neck. For lipid residue analysis, loose skin was also sampled.

M25 - adult, probable female, 777–544 cal. BCE

This individual consists of a partially bandaged and skeletonized cranium with an articulated mandible and cervical vertebrae, with wrappings preserved mainly on the right side and arranged

in longitudinal and transverse layers. Anteriorly preserved mummified tissues display light, crystalline surfaces, especially around the eyes and left cheek, while the posterior cranium is exposed, revealing clear sutures. The cervical vertebrae remain articulated, and mummified tissues are present, though the vertebral canal is empty; internal material is seen within the cranial cavity. CT scanning reveals that all permanent teeth have erupted and have observable occlusal wear. CT scanning also shows that the ethmoid was fractured and the brain was removed and replaced by embalming material.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the front of the neck.

M33 - adult, probable male, 786–551 cal. BCE

This individual consists of a partially skeletonized cranium and articulated mandible and cervical vertebrae largely devoid of wrappings, except for minimal textile remnants behind the right ear. The left side of the face is partly skeletonized, while the right retains mummified skin, ocular tissues, and nasal packing; both ears are present, and the mouth is partially open and filled with bandages. The crowns of the anterior teeth are chipped and damaged, perhaps in relation to the “Opening of the Mouth” funerary ritual. Short dark hair remains on the cranial vault. The cervical vertebrae are preserved and articulated, with no embalming material in the vertebral canal. CT scanning indicates that all permanent teeth have erupted and that the ethmoid was fractured and the brain was removed. There is also trauma to the frontal bone above the left orbit.

For radiocarbon dating and lipid residue analysis, textiles were sampled from inside the cranium.

Late Period

M49 - adult, sex indeterminate, 415–372 cal. BCE

This individual is represented by a partially skeletonized cranium and articulated mandible. The frontal and upper parts of the cranial vault are absent, and both ears are preserved. Traces of bandages adhere to the mummified tissues of the cranial vault, and ocular tissues are visible in the left orbit. The mouth is slightly open, and visual observation shows that all permanent teeth have erupted and have a moderate degree of wear. The endocranium is empty, and it is unclear whether the brain was intentionally removed.

For radiocarbon dating and lipid residue analysis, loose textiles were sampled because they were all that could be collected without substantially damaging the individual's integrity. Further, prior analysis was conducted detailing tissue preservation (Stani et al. 2014).

Late Period/Ptolemaic

M23 - adult, sex indeterminate, 377–201 cal. BCE

This individual consists of a mummified cranium and articulated mandible and cervical vertebrae, partially wrapped in compact bandages. The neck is encircled by more flexible, loosely adhered wrappings. Exposed mummified tissues are well preserved and very dark in coloration, and they appear coated with a black external substance. Anatomical features include a closed right eye, dilated empty nostrils, a slightly open mouth with well-defined lips, and the right ear. Inferiorly, the cervical vertebrae are articulated, and the vertebral canal is empty. While the permanent teeth are not visible to the naked eye, CT scanning reveals that all are fully erupted. CT scanning also shows that the ethmoid is fractured and the brain was removed.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the right side of the neck

M29 - child (7.5-8.5 years), sex indeterminate, 386–206 cal. BCE

This individual consists of a partially skeletonized cranium, articulated mandible and cervical vertebrae with fragments of rigid bandages. Parts of the cranial vault are exposed, with unfused cranial sutures visible. Inferiorly, cervical vertebrae with mummified tissues are present, with an empty vertebral canal. Dark mummified tissues are preserved across the face, including on the ears, nose, and mouth. The dentition is partly visible, with the permanent first molars appearing to be fully erupted behind the deciduous molars. The CT scan shows the crowns of the permanent second molars and incisors without the roots having initiated, which helps narrow the age estimate down to between 7.5 and 8.5 years old (AlQahtani et al. 2010). Using CT scanning, we can identify that the brain was removed via the nasal passage as the ethmoid is fractured.

For radiocarbon dating and lipid residue analysis, textiles were sampled from above the right ear.

M42 - young adult, probable male, 386-207 cal. BCE

This individual consists of a partially bandaged cranium and disarticulated mandible (without retained cervical vertebrae). Dark, rigid, and tightly adhered bandages cover the anterior and superior regions, beneath which mummified soft tissues are preserved. The posterior and inferior portions of the head are fully skeletonized, exposing cranial sutures that are visible but not yet fused. The preserved permanent teeth show minimal wear. CT scanning reveals that the brain was removed; however, the ethmoid is complete, and it can be suggested that the brain was removed through an alternative method.

For radiocarbon dating, loose textiles were sampled; textiles from the head were avoided because they were too rich in embalming material. For lipid residue analysis, recently detached textiles that were clearly from the head were sampled.

M36 - middle-aged/old adult, probable female, 381-206 cal. BCE

This individual consists of a partially skeletonized cranium and articulated mandible. Fragmentary bandages of differing weaves, rigid and tightly adhered, remain on the forehead and parts of the face. Mummified tissues persist anteriorly, while the sides and back of the cranium are exposed, with partially fused but visible sutures and an empty cranial cavity. The orbits contain bandages and mummified tissue. The mouth is slightly open and skeletal, with several teeth lost ante-mortem. CT scanning reveals that all permanent teeth have erupted, and there is extensive wear. The brain was removed via the nasal cavity, causing the ethmoid to fracture.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the forehead.

Ptolemaic

M9 - adult, probable male, 361–52 cal. BCE

This individual consists of a mummified cranium and mandible (without neck), heavily covered by multiple layers of bandages of differing weaves. A large lighter-colored textile piece covers most of the face beneath additional wrappings. Anatomical structures are minimally visible: the right temporal region through a sampling window, a portion of the left lambdoid suture with a sutural bone, and hair on the crown coated in a dark substance. Inferiorly, the head is largely skeletonized, with amorphous material within the cranial cavity. CT scanning confirms that this is the brain. The preserved posterior dentition shows limited wear and a carious lesion on the left second premolar, and ante-mortem loss of the first molar. The ethmoid is not fractured, and no attempt was made to remove the brain.

For radiocarbon dating and lipid residue analysis, textiles were collected from the back of the crania.

M37 - adult, probable female, 341–53 cal. BCE

This individual consists of a partially bandaged cranium with the mandible detached and skeletonized. Wrappings cover the anterior and right lateral portions of the cranium, becoming increasingly fragmented posteriorly and inferiorly. Mummified tissues persist but are variably deteriorated, and dark curls of medium-length hair remain on the crown. Parts of the left side and back of the cranium are exposed, with partially ossified sutures and an empty cranial cavity. The left orbit contains mummified tissue, the nose is preserved but empty, and both permanent maxillary and mandibular teeth are present with minimal wear aside from post-mortem incisor loss. CT scanning shows the ethmoid is fractured, and the brain was removed through the nasal cavity.

For radiocarbon dating and lipid residue analysis, loose textiles were sampled. These likely originate from the left side of the front of the face.

M39 - child (12-13 years old), sex indeterminate, 342–54 cal. BCE

This individual consists of a partially skeletonized cranium and disarticulated mandible. Anteriorly, rigid bandage remnants and mummified tissues are preserved, and hair remains on the superior surface of the cranial vault. The head displays overall dark, glossy black coloration with some reddish tones, while the posterior cranium is exposed, showing visible sutures and a sutural bone. Both orbits and the nasal cavity are empty, and the mouth retains its teeth, with some anterior crowns fractured. This damage may opening relate to the “opening of the mouth” ceremony. The cranial cavity is empty. The permanent first molars are fully erupted, and the crowns of the second molars have begun to erupt. CT scanning shows the ethmoid is fractured, and the brain was removed through the nasal cavity.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the right side of the head near the temple.

M44 - young adult, sex indeterminate, 353–111 cal. BCE

This individual consists of a partially skeletonized cranium, heavily wrapped in dark, tightly adhered bandages that encircle the superior, posterior, and left lateral regions in multiple compact layers up to 5 cm thick. The right side and inferior portions show exposed mummified tissue remnants beneath the wrappings. The right orbit and nasal cavity are empty and fully visible, while the left orbit remains covered by bandages; the permanent dentition is preserved in situ, including an erupting third molar. CT scanning shows the ethmoid is fractured, and the brain was removed through the nasal cavity.

For radiocarbon dating and lipid residue analysis, textiles were sampled from the left side near the cheek.

M52 - adult, probable male, 356–119 cal. BCE

This individual consists of a partially skeletonized cranium, retaining anterior fragments of bandages adhered to dark, sometimes glossy mummified skin and scalp with isolated hair tufts. Portions of the cranial vault are exposed, with sutures still partly visible. Both orbits and the nasal cavity are empty, and only four permanent teeth remain, with evidence of ante-mortem loss. The cranial cavity is empty. CT scanning shows the ethmoid is fractured, and the brain was removed through the nasal cavity.

For radiocarbon dating and lipid residue analysis, loose textiles were sampled. These were collected in favor of textiles on the skull to avoid visible contaminants.

M60 - adult, probable female, 376–198 cal. BCE

This individual consists of an almost completely skeletonized calvaria (the maxillae are present but the basicranium is missing) and disarticulated mandible. Small areas of black and sometimes glossy mummified tissue and bandage fragments adhere to the cranial surfaces. Glossy resinous material is also attached to the inner surface of the cranial vault. The mandible retains all permanent teeth with marked anterior wear, while the maxilla has lost several teeth ante-mortem. Cranial sutures remain partly visible, and several detached bone and tissue fragments accompany the specimen.

For radiocarbon dating and lipid residue analysis, loose textiles were sampled.

Roman

M69 - adolescent/young adult, sex indeterminate, 83-218 cal. CE

This individual consists of a mummified cranium, without the mandible and neck. Elements of the bandages are present superiorly and anteriorly, leaving the mummified tissues of the face and head exposed. The face is covered with a layer of gold leaf that partly overlaps with the bandages. The individual has short, dark hair. The eyes are half-closed, and bandages are visible inside; the eyelashes are preserved. The nose is complete, with empty nostrils. All the maxillary permanent teeth show slight wear; some tooth sockets are resorbed, and the remaining anterior teeth are fractured post-mortem. The fractures could relate to the “Opening of the Mouth” ceremony. CT scanning reveals that the brain is present and no attempt was made to remove it through the ethmoid.

For radiocarbon dating, textiles were sampled from the posterior of cranium. Loose hair was also sampled for lipid residue analysis.

Other partially studied individuals

In addition to the above-mentioned individuals, three individuals were incompletely studied and as such were not included in this paper. Individual M3 was radiocarbon dated but not analyzed by GC-MS, while individuals M6 and M41 did not yield sufficient carbon for radiocarbon dating and correspondingly were not analyzed by GC-MS.

M3 – old adult, sex indeterminate, 768–520 cal. BCE

This individual consists of a mummified cranium, articulated mandible and neck partially covered by circular and oblique layers of bandages. A deep gap on the right cheek exposes underlying tissues and the fractured right mandible. Several anatomical elements and a cervical vertebra in correct anatomical position and articulation with the vertebrae above are recognizable. Save for

what appears to be a left mandibular canine, the maxillae and mandible are edentulous with advanced alveolar resorption. Inside the vertebral canal, macroscopic traces of biological tissue are present. CT scanning confirms that this is likely desiccated brain tissue. The ethmoid is complete, showing no attempt was made to remove the brain through the nasal cavity. For radiocarbon dating, a textile sample was collected from the neck area at the back of the head.

M6 - adult, probable male

This individual consists of a mummified cranium, articulated mandible and neck, largely devoid of bandages aside from residual textile fibers on the face. The preserved facial tissues show brown to black coloration with occasional sheen. The eyes, nose, ears, and a closed mouth with a retracted upper lip and beard hairs, are identifiable. Portions of the scalp and short dark hair remain on the frontal, lateral, and nuchal regions, while superior and inferior cranial areas lack soft tissue, revealing bone marked by slight porotic hyperostosis and visible cranial sutures. The neck displays an incision from postmortem separation; internal structures, including an articulated cervical vertebra with residual cartilage, are visible. Linear enamel hypoplasia is observable on the crowns of the exposed maxillary incisors.

For radiocarbon dating, textiles were sampled from the back of the head near the neck.

M41 - adult, sex indeterminate

The individual consists of a partially skeletonized cranium only. Fragments of dark brown rigid bandages are preserved. On top of the cranium there are mummified tissues and short brown hair. The eye sockets and cranial cavity are empty, and the extant permanent teeth are not particularly worn.

For radiocarbon dating, loose textiles were sampled.

References

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