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Rescanned: new Results from a Child Mummy at the University of Illinois

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Abstract

In March of 2011, a Roman-period Egyptian mummy belonging to the Spurlock Museum of the University of Illinois was re-scanned after a twenty year interval, using new Computed Tomography (CT) equipment and image reconstruction software. The original goals of the project were to study the embalming techniques and the age, sex, and cause of death of the child inside the wrappings. Initial results showed that the mummy was a child, aged seven to nine years at the time of death, who was placed on a wooden board without obvious evisceration (brain, heart, and lungs still remain), and wrapped in a red shroud with a typical face portrait and decorations. Although the new images did not reveal the sex of the mummy, they did show significant damage to the back of the head and clearer images of internal organs and cloth packing than twenty years ago.

Introduction

The Spurlock Museum at the University of Illinois curates an Egyptian mummy (Fig. 1), dated to the early second century A.D. (Roman period) by the painted and gilded depictions of Egyptian gods and goddesses on its red stucco cartonnage and the poorly preserved face portrait. The mummy originated from the Fayum oasis district, a center of Greek and Roman settlement in Egypt beginning with the reign of Alexander the Great. The specific site or cemetery of origin is unknown.

In 1990, before the mummy was placed on exhibit, a university research team led by Wisseman investigated the mummy using non-invasive medical imaging and limited materials analysis. Our research focused on two areas: the body itself, and the embalming procedures. What was the age, sex, medical history, diet, and cause of death of the person inside the wrappings? Were the emblaming procedures consistent with those from other mummies dating to the Roman period? Do they support the evidence of the elaborate exterior that the individual was from the upper class of Egyptian society?

In 2011, members of the 1990 team decided to rescan the mummy for two reasons: many questions still remained about the mummy's life and death, and both CT scanning technology and computer reconstruction of CT slices have come a long way in twenty years.

Materials and methods

In the 1990 investigation, plain film radiographs (Fig. 2) and Computer Assisted Tomography (CT) scans (10 mm intervals for the body; 5 and 3 mm intervals for the head) were examined by a team including a radiologist, a radiographer, a forensic anthropologist, and a local dentist. A re-investigation of the mummy was performed in 2011 using a GE LightSpeed scanner (16 slice, 0.625 mm slice thickness) at smaller intervals to produce images of much higher resolution.

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Fig. 1. Spurlock mummy with portrait panel and iconic figures on the front of the mummy typical of the Roman period. Note the red coloration of the mummy from the minium (lead oxide) pigment. – Photo by B. Weigand, UIUC News Bureau.

Initial imaging results showed that the mummy was a child with an occipital fracture. Internal organs (brain, lungs, and heart) were still in place, and a wooden "stiffening" board was placed under the body, inside the wrappings. In addition to X-rays and CT scans, the team was able to collect tiny samples of cloth, resin, wood, insects, bone, and the red pigment on the stucco surface from the damaged area around the feet of the mummy. Analyses showed that the mummy was wrapped in linen, the board was a type of African cedar, the embalming fluids included both coniferous resins and bitumen, the red colorant was a lead oxide, and necrobic beetles were present (Wisseman 2003). Our child mummy is similar to the Roman-period child mummy PUM IV (Pennsylvania University Museum no. 4) in the use of a board and the poor condition of the mummified flesh (Wisseman 2003: 45, 51). A reanalysis of the red colorant in 2009 by Getty Conservation Institute further identified the pigment as minium from Spain, tying the Spurlock mummy to nine other "red shroud" mummies from the Roman period (Corcoran & Svoboda 2010).

Results

The 1990 radiographic investigations determined that the mummy was a child, approximately seven to nine years old. The presence of completely open epiphyseal growth plates at the end of the long bones and both deciduous and permanent teeth in the jaw (Fig. 3) indicated that the child was between six to ten years at time of death.

The 2011 images of the long bone lengths (Fig. 4) suggested a child approximately 6.5 years while the new scans of the head illustrated the dental development of a child approximately nine years of age (Scheuer & Black 2000, Moorrees et al. 1963). The disparity in the ages may be an indication of some nutritional stress, dental growth being more genetically driven to stay on course than more environmentally-effected skeletal growth.

The sex of the individual was not determined in either investigation. Due to heavy use of embalming fluids and thick cloth wrappings with higher densities, no clear illustration of the genitalia could be made. The collapse of the pelvis, and the separation of the pelvic bones from their anatomical position (Fig. 5) did not allow measurement of the pelvic girdle to attempt sex assessment using Reynolds (1947). The densities of deteriorating bone, dried tissue, and cloth wrappings are so similar in places that, even with higher resolution images, it is not yet possible to isolate the pelvis from surrounding materials (Fig. 6).

Fig. 2. Plain film radiograph of Spurlock mummy head and shoulders produced in 1990 showing dental features and densities in the wrappings. – R. Keen, UIUC Vet Medicine.

Fig. 3. CT 3D image of the left lateral side of the skull illustrating the dentition. Note the erupting permanent canines, premolars and second molars. Note also the resorption of the second deciduous molar roots by the eruption of the second premolar.

Fig. 4. Coronal cross-section CT image of pelvis and lower extremities illustrating the measurement of the right femur and tibia.

However, new imaging software does make it possible to see some features of the mummy much more clearly than before. Using OsiriX, external layers can be removed, textures and density gradients enhanced, and remarkably detailed images of bone, soft tissue, and cloth packing and wrappings can be produced from the CT data (formatted as Digital Imaging and Communications in Medicine [DICOM] files).

The 1990 CT scans showed an occipital skull fracture. The origin of the defect is not obvious, but this occipital damage is consistent with late period mummification practices seen in other Greco-Roman mummies, especially children. The more detailed 2011 CT scans (Fig. 7) gave finer illustration of the cranial fractures and their extent. Through segmentation of the images from the cranium, it was possible to identify that the occipital *pars lateralis* was located inside the cranium (Fig. 8).

Other features illustrated by the 2011 CT examination are: a possible hair lock or bundle on the left side of the cranium (Fig. 9), layers of wrappings,

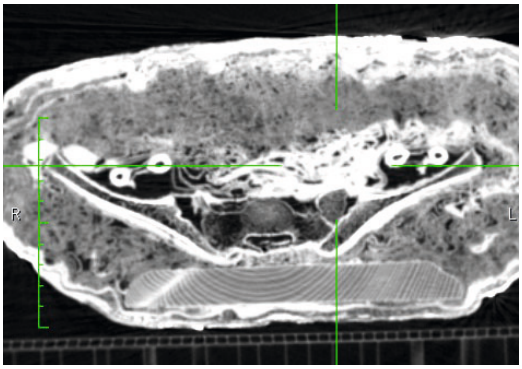

Fig. 5. Transverse cross-section CT image though the mid-pelvis illustrating the ilia and sacrum. Notice the separation of the sacro-iliac joints by the dorsal flattening of the ilia. Stiffening board is illustrated, showing its placement at the back of the mummy and inside the wrappings.

Fig. 7. CT 3D image of the dorsal aspect of the cranium, illustrating the bony fractures of the dorsal right parietal and inferior occipital and basilar region. Note also the illustration of the dentition.

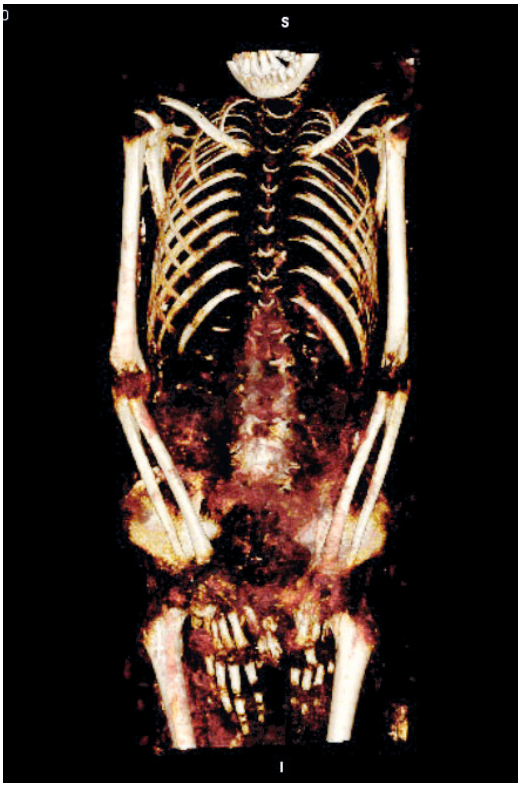

Fig. 6. CT 3D image of the thoracic and pelvic region of the Spurlock mummy produced in 2011.

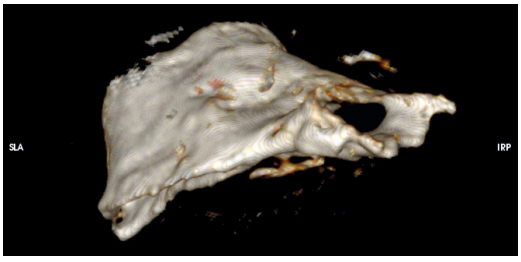

Fig. 8. CT 3D image of the *pars occipitalis* located in the endocranium.

wads of "fill-in" linen packing (Fig. 10), a roll of cloth under the head (Fig. 11, seen also in 1990), resin treatment on the body surface and to the external surfaces of the mummy wrappings, and a wooden "stiffening" board (Fig. 12) the wrappings. Heart and lungs were visible inside the chest cavity, and remnants of brain tissue were still present; there is no evidence of damage to the nasal region for brain removal, as was practiced in earlier dynasties.

In 1990, the two-dimensional (2D) CT scans enabled Raymond Evenhouse at the VR Medical Laboratory at the University of Illinois at Chicago to produce a sculpture of the mummy's head by cutting out Styrofoam™ forms of the CT slices by hand and stacking them to re-create the skull. Blue skin tissue depth markers were added, based on Helmer's (1984) ultrasound and anatomical studies, and modeling

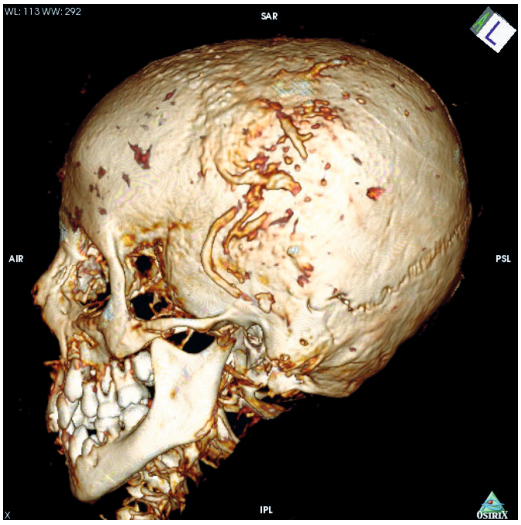

Fig. 9. CT 3D left lateral skull image illustrating densities on the left lateral side of the cranium. These are likely hair clumps that have been made denser by embalming materials.

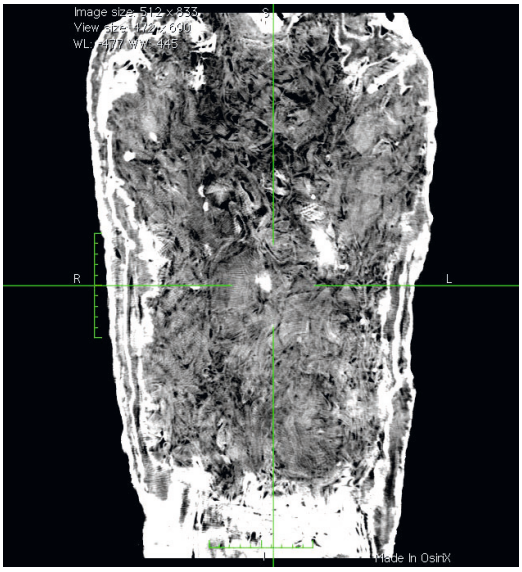

Fig. 10. Coronal CT cross-section image illustrating the cloth packing in the anterior chest region of the mummy.

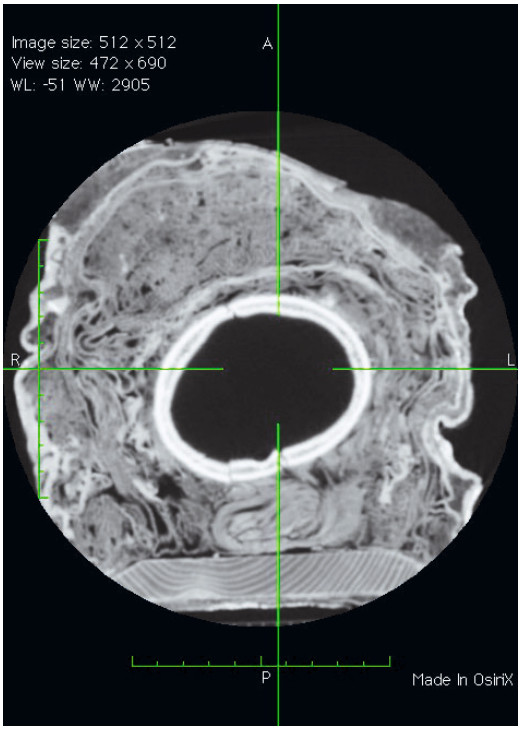

Fig. 11. Transverse CT cross-section image of the cranium illustrating the layers of wrapping and folded cloth 'pillow' under the cranium. Also note the stiffening board under the head.

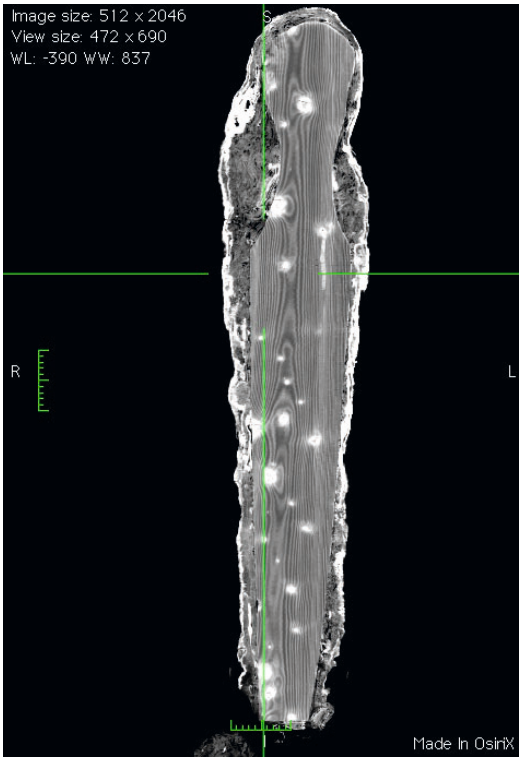

Fig. 12. Coronal CT cross-section image of the stiffening board.

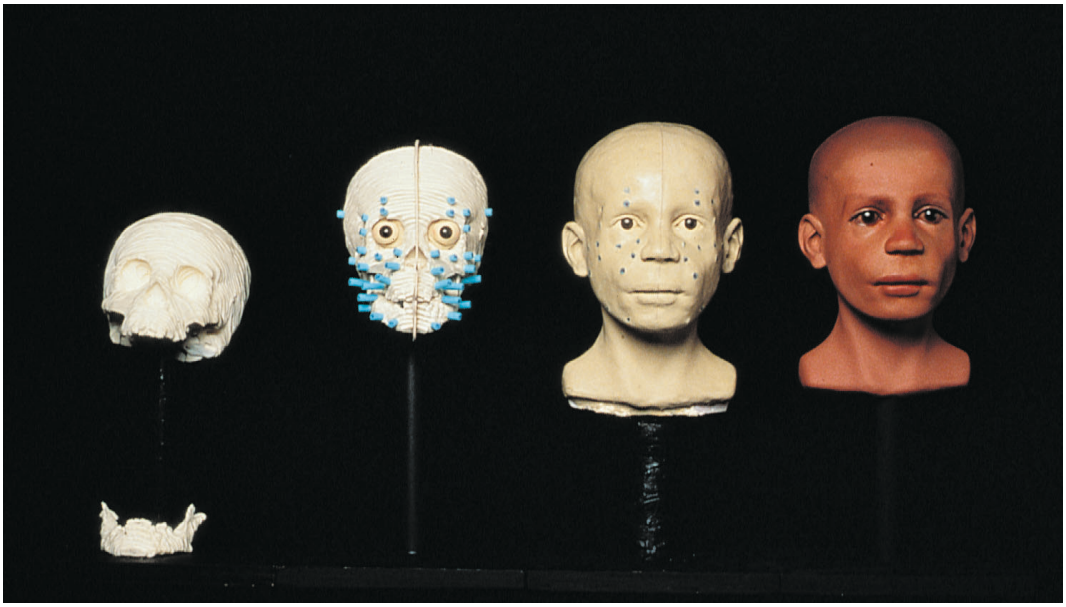

Fig. 13. Stages of the 1990 reconstruction of the skull and face. – Raymond Evenhouse (University of Illinois at Chicago).

clay was layered onto the skull reconstruction to rebuild a face. The result was a sculpture of the child's face at the approximate age of eight with some prognathism (protrusion of the jaw), implying a child with some Negroid ancestry (Fig. 13).

In 2011, a reexamination of the jaw showed no prognathism and a skull much more consistent with West Asian ancestry. Accordingly, Joe Mullins, forensic artist at the National Center for Missing and Exploited Children adjusted the facial reconstruction (Fig. 14) of the child using the SensAble Technologies FreeForm® sculpting software. This system is used to build a three-dimensional (3D) image of the face from the 3D skull image produced from the CT scans. The skin tissue thicknesses and the tissue layering were all executed virtually.

Discussion and conclusions

Non-invasive investigation of mummies using radiographic CT imaging is now the norm rather than full autopsy, because the artifact is preserved while researchers can extract data about the life and death of the person inside. In the case of the Spurlock Museum mummy, the new CT scanning technology and enhanced imaging software available today compared to twenty years ago has increased our understanding of mummification during the Roman period by yielding more specific information about the person inside the wrappings.

All of the evidence from both studies, combined with the Getty analysis of the red colorant on the stucco covering, connected this child mummy to nine other high status mummies in the "red shroud group" (Corcoran & Svoboda 2010). This confirmed the original conclusion that this mummy child was from a well-to-do family that could afford expensive ingredients such as gold gilt and minium pigment from Spain.

It is unlikely that the question of sex will be solved without a successful DNA analysis (already attempted twice with no results). However, some questions remain that may be answered by further manipulation of the 3D data from the new DICOM files. Wisseman is currently using Amira® 5 software to investigate whether or not the embalmers actually tried to remove the brain through the back of the head rather than through the sphenoidal sinus and whether the stiffening board may have served a ritual function as well as a supportive one.

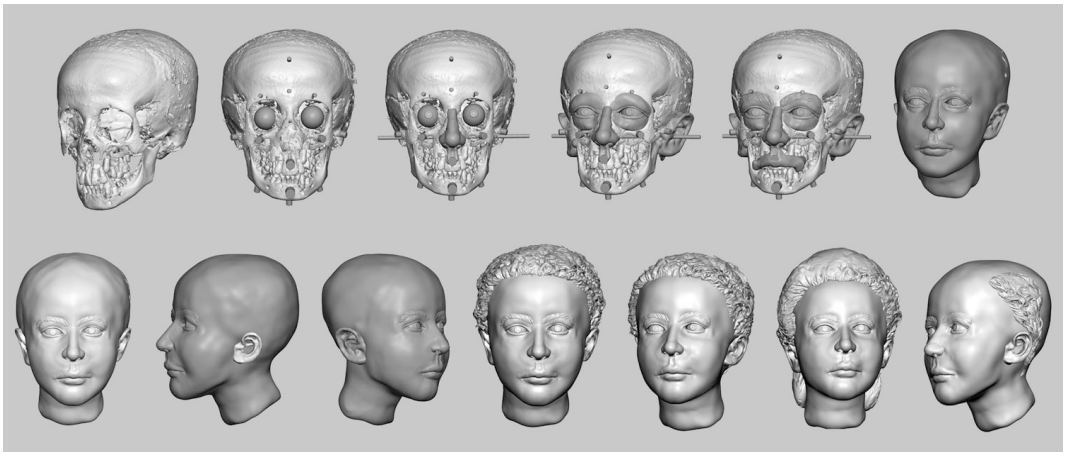

Fig. 14. Stages of the 2011 facial reconstruction using 3D CT skull reconstruction as basis for virtual reconstruction using Sensable Technologies FreeForm. Hair styles were derived from Fayum portrait boards. – Joe Mullins, forensic artist.

Egyptian child mummies are uncommon in the archaeological record, particularly in the Roman period. Further investigations focusing on children who were mummified, their embalming procedures, the status of these individuals, and the health and cause of death likely will shed further light on Roman period practices.

Acknowledgments

Over twenty University of Illinois, Urbana Campus (UIUC) units and two local hospitals participated in the Spurlock Museum mummy project (see complete list in "The Virtual Mummy" and on our website: http://www.isas.illinois.edu/atam/research/mummy/index.html).

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