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The UQAM Mummy – The Use of Non-Destructive Imaging to Reconstruct an Ancient Osteobiography and to Document Modern Malfeasance

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Introduction

An Egyptian mummy and her coffin dating to the 26th Dynasty were donated to the École de Beaux Arts in Montreal in 1927. This mummy has been in the collection of the Université du Québec à Montréal since 1967. Inscriptions on the elaborate coffin identify the individual as *Hetep-Bastet*. In 1969, the mummy was attacked by a protester, who caused extensive damage. The mummy was scanned once over a decade ago. However, computed tomography (CT) technology has advanced a great deal since that time, and some conclusions reached were somewhat suspect (e.g. that she suffered from a large dental abscess caused by "drinking too much beer"). Thus, when *Hetep-Bastet* was transported to Gatineau in the fall of 2008 to be part of the "Tombs for Eternity" exhibit at the Canadian Museum of Civilization, we took the opportunity to rescan her.

The specific goals of our study were:
- to assess the damage done by the protester in 1969
- to investigate the specific details of how she was mummified as part of an ongoing study of variability in mummification practice
- to gather osteological and paleopathological data in order to reconstruct her osteobiography
- to segment the skull from the CT data in order to create a facial reconstruction
- to examine her coffin as part of an ongoing study of the use of CT scans to characterize different materials associated with Egyptian mummies

Damage to the Mummy

Scans revealed that the neck and thorax of the mummy were extensively damaged in the protester's attack. The entire spine was affected, and only a few lumbar vertebrae are still in anatomical position. The ribs, vertebrae and clavicles have all collapsed into the posterior half of the thoracic cavity. Thus, the head is no longer connected to the spinal column. It is not unusual for a few bones to be out of position in Egyptian mummies (Gardner et al. 2004), but this degree of damage is exceptional.

It would appear that when the mummy was pushed to the ground the head and shoulders hit first. The shock separated the head from the neck and dislodged the contents of the thoracic cavity. The thoracic contents were contained within the shell of the skin and wrappings and settled inferiorly and posteriorly when the mummy was raised back up shoulders first and placed in a supine position. The arms, hands pelvis and legs were held in position, as they were individually wrapped. Unfortunately, we do not know when in her afterlife, Hetep lost her feet.

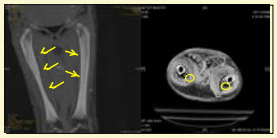
Method of Mummification

It is commonly assumed, following Herodotus, that all mummies who had their brains removed were excerebrated through the nose. However, the brain is absent in this individual (except, possibly, for a small piece in the rear of the skull), while the turbinates, nasal septum, sphenoid, and ethmoid air cells remain completely intact. There are no obvious holes in the vault of the skull, suggesting that the brain was probably removed through the foramen magnum. Transforaminal craniotomy, is not a well-documented or well-understood excerebration technique and only a handful of likely examples have been reported (Wade et al., Forthcoming). A regional distribution pattern for this technique has been proposed (Lamb, 1901; Shafik et al., 2008) in which this method was carried out by a school of embalming in Memphis (see the coffin section), as opposed to the transnasal craniotomies carried out by a school in Thebes. This hypothesis can only be tested using systematic examination of well contexted mummies.

The damaged condition of the thorax makes it difficult to assess whether and/or which organs were removed during evisceration. The presence and positioning of packing material in the abdominal cavity suggests that at least the abdominal organs were removed through an incision in the left abdominal wall (see image above).

The limbs were wrapped individually. Packing was inserted around the arms and between the legs before a final layer of linen was used to wrap the entire body.

Indicators of Health and Disease



The stature of this individual is estimated to be 162.8cm, based on humerus length using the formulae from Trotter (1970). This is slightly above the published mean for ancient Egyptian females (157.5cm ±5.2cm) (Zakrzewski 2003).

A close examination of the thigh region of this mummy revealed evidence of arteriosclerosis. This condition is known to have affected the occupants of ancient Egypt (Ruffer 1911, Sandison 1962), but is interesting in this case because it is most common in men rather than women. There are a variety of causes, including high cholesterol, diabetes, hypertension and so on, and the most common symptom is pain in the thighs.

This individual suffered from very poor dental health. She had lost all but one of her lower teeth and had only seven relatively intact upper teeth.

Other pathological conditions noted include a subchondral cyst of the right lunate bone, degenerative changes of both hips, but especially the left, and subchondral cysts of the distal articular surface of the right tibia. Mild osteopenia was noted throughout the skeleton.

Image Segmentation and Facial Reconstruction

The segmentation of a CT dataset from an Egyptian mummy can be very challenging due to gray scale compression and the presence of bone-like materials. The segmentation of the skeleton of the UQAM mummy is particularly challenging because of the scrambled nature of her thorax . The segmentation of the skull, for the purposes of extraction for facial reconstruction, is made difficult by the presence of a dense resin, which appears to have been smeared on the face and in the wrappings immediately surrounding the face.

We are working to overcome both these problems by using a dual energy post-processing technique (Friedman et al. in press). Dual-energy CT uses two sets of images acquired at different x-ray energy levels and relies on the differing interactions between x rays and the mummy depending on both the materials present and the x-ray energy. Dual-energy CT has been used to image small animals (Granton et al. 2008) and on human patients in clinical settings (Johnson et al. 2007), but to the best of our knowledge, no previous attempts have been made to apply the technique to mummies.

The whole body image to the right was produced using this technique. We are using the modeling of the skull as a case study to compare traditional segmentation techniques to the dual-energy technique.

The Coffin

While there is no known provenance for *Hetep Bastet's* coffin, the texts and decorations suggest that it was made in the north of Egypt, probably Memphis (opinion expressed by John Taylor of the British Museum) (see the mummification section). The coffin is covered with paintings and hieroglyphic text. The texts are written in five columns and include funerary phrases, names and words of the Gods. The coffin was also damaged during the 1969 attack but it was painstakingly restored by the conservators at the Canadian Museum of Civilization.

photo credits Justin Lenczewski
Canadian Museum of Civilization

When we scanned the mummy, we also scanned a piece of the back of the coffin. Several interesting observations can be made from the scan. First, the surface of the coffin appears to have been treated with a thin layer of dense material. This may be a clay or plaster based mordant applied to aid with the adhesion of the paint to the coffin. Second, the construction technique using wooden pegs can be seen. The peg is a denser wood than the main boards. It is likely that the main wood is sycamore fig and the pegs are tamarisk, but identification will require the identification of wood species from their CT characteristics. This work is presently underway. Finally, the ring structure of the wood is easily seen.

Ongoing Research

This work is part of an ongoing research program looking into the use of non-destructive imaging techniques in mummy studies. This interdisciplinary effort brings together a large team of scholars from many different institutions, focusing their individual expertise to the common goal of maximizing the recovery of information from these invaluable time capsules.
Specific research projects include:

1) the establishment of an internet based collaborative database of radiological studies of mummies;
2) the empirical study of patterns of mummification practices through time;
3) the development of post-processing techniques (dual energy) to aid in image segmentation;
4) the use of post-processing techniques (dual energy and texture analysis) to identify specific materials placed within mummies.

Please see handout for acknowledgements and literature cited