Computed tomography scanning of Meresamun

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Very detailed 3D scans of a 3000-year-old mummy of an Egyptian temple singer and priestess are made freely available for in-depth follow-up studies.

We recently obtained two sets of computed tomography (CT) scans of the Meresamun mummy, which had been present at the Oriental Institute since the 1920s but was never opened. In July 2008, we decided to obtain an up-to-date CT scan, in anticipation of a new exhibit featuring Meresamun. The mummy had been scanned at the University of Chicago in 1991 with a single-slice CT scanner, so it was not clear what kind of ‘new’ information, if any, could be extracted. On the basis of an extensive review of the literature on mummy-CT scanning, we are aware of only one paper in which a multidetector row-CT scanner featuring more than 16 channels was used, and then only to examine the mummy’s head.¹

We used a 64-channel Philips Brilliance 64 clinical scanner to acquire a set of spiral-CT scans after the mummy had been crated and transported to the University of Chicago Medical Center’s radiology department. All mummy handling was performed by museum staff, supervised by curators and conservators. The mummy’s casket was carefully placed on the scanner table. Both full-body and local scans were obtained, the latter of the head and shoulders, torso, lower extremities, and feet. Each of these data sets was post-processed using a Philips Brilliance version 3 workstation to generate multiplanar reconstructions (MPRs) and 3D images. The data was archived on CDs and DVDs, and analyzed using an Apple MacBook running the Osirix open-source operating system.

Figure 1. Unopened casket of Meresamun in the 256-slice computed tomography (CT) scanner.

Figure 2. Reconstructed 3D lateral view of the mummy’s head and neck, with the left half of the coffin removed. Note how the chin contacts the coffin’s front inside wall. The skin remains and the mummy’s external ear is visible.

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Figure 3. Lateral view of the coffin containing the mummy, generated as a simulated radiograph.

Based on our experience with the 64-slice scanner, approximately 5000 slices were created, which were used to generate 1000 reconstruction images and sequences. Inspection of the results revealed many previously unrecognized details, including subtle post-mortem fractures of the upper skeleton, dental features, jewelry, radiodense inclusions in the casket, and degenerative changes in the spine.

In September 2008, a 256-slice CT scanner was installed in the radiology department. The newly constructed room required inspection by the Illinois Department of Public Health for conformance to safety standards. In the meantime, the mummy

Figure 4. Scout view of the CT-scanner console.

Figure 5. Midsagittal-slab view, showing the spinal canal leading to the base of the skull. The mummy is surrounded by linen wrapping as well as the casket. Packing material has been placed in the mouth, neck, and upper thorax.

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was crated and returned to the radiology department for a second set of scans and became the first ‘patient’ to be examined with the new scanner (see Figure 1). We acquired seven data sets of the head and neck, torso, whole casket, lower extremities, and feet. The raw projection data sets were saved (∼ 30Gb), together with approximately 25,000 reconstruction axial images. Subsequently, we repeatedly reconstructed the raw projection data by varying the relevant parameters (e.g., center, magnification, filters, thickness, and matrix size), thus yielding about 100,000 axial slices. Using a Philips Brilliance 4.0 workstation (a major upgrade and better suited to the very large data sets acquired with the 256-slice scanner), we generated MPRs and 3D views (see Figure 2), and made numerous movie sequences. Post-processing has yielded edited files of the disarticulated skeleton, local and regional organ studies, overlays, and solid models. We also generated stereolithography files to enable life-size modeling. The results of the 256-slice CT scans far exceeded our expectations, and to date this mummy may have been studied more exhaustively with CT than any other (see Figure 3). Although numerous books, journal articles, reports, and news articles discuss CT scanning of mummies, no comparable examination exists in terms of the details found, number of images generated, technical specifications of the imaging system, and computer-graphics results (see Figure 4).

The announcement of the new Meresamun exhibit excited significant media interest and resulted in numerous news reports (e.g., on CNN), magazine articles (most notably in *Archaeology*), which also created a dedicated website, and many other outlets. A special monograph, authored by numerous experts and edited by world-leading authorities in Egyptology, was developed to complement and catalog the exhibit.3

There are several unusual aspects to this study. Most important, all experts who worked on this project agreed to freely share all data obtained, which will be made available online (see Figure 5). To those who do not have access to a 256-channel CT scanner and unopened mummy in a casket, this therefore offers a unique opportunity to continue and expand our studies.

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