

# Scenes from the Past

## Common and Unexpected Findings in Mummies from Ancient Egypt and South America as Revealed by CT<sup>1</sup>

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Computed tomography (CT) has proved to be a valuable investigative tool for mummy research and is the method of choice for examining mummies. It allows for noninvasive insight, especially with virtual endoscopy, which reveals detailed information about the mummy's sex, age, constitution, injuries, health, and mummification techniques used. CT also supplies three-dimensional information about the scanned object. Mummification processes can be summarized as "artificial," when the procedure was performed on a body with the aim of preservation, or as "natural," when the body's natural environment resulted in preservation. The purpose of artificial mummification was to preserve that person's morphologic features by delaying or arresting the decay of the body. The ancient Egyptians are most famous for this. Their use of evisceration followed by desiccation with natron (a compound of sodium salts) to halt putrefaction and prevent rehydration was so effective that their embalmed bodies have survived for nearly 4500 years. First, the body was cleaned with a natron solution; then internal organs were removed through the cribriform plate and abdomen. The most important, and probably the most lengthy, phase was desiccation. After the body was dehydrated, the body cavities were rinsed and packed to restore the body's former shape. Finally, the body was wrapped. Animals were also mummified to provide food for the deceased, to accompany the deceased as pets, because they were seen as corporal manifestations of deities, and as votive offerings. Artificial mummification was performed on every continent, especially in South and Central America.

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**Abbreviation:** MIP = maximum intensity projection

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## Introduction

Ancient human mummies have always been a source of fascination. It is therefore not surprising that the scientific interest in mummies is huge. Because of this interest, many Egyptian mummies have been unwrapped and have undergone autopsies of questionable scientific nature and subsequent destruction in centuries past. Thus, the careful and highly efficient work of ancient embalmers, who aimed at preserving human remains for eternity, became a victim of the scientific interest of later generations.

By contrast, modern paleopathologic researchers try to find a method to investigate objects while not destroying them. Therefore, radiologic investigative techniques, by virtue of being noninvasive and hence nondestructive, are of inestimable value in the field of modern paleopathology. One such method, radiography, was often used to make visible the contents of wrapped mummies. However, a shortcoming of this technique is that the mummy's three-dimensional information is reduced to a two-dimensional image. Although skeletal features can be sufficiently detected with this method, a satisfactory characterization of wrappings, contents, and mummification techniques is not possible.

Computed tomography (CT) has proved to be a valuable, noninvasive investigative tool for mummy research since as early as 1979 (1) and remains the method of choice for examining mummies. This technique allows for noninvasive insight, whereas dissection destroys characteristic features of the object and often makes a subsequent exposition to the public impossible, as the unwrapping and autopsies performed on mummies in previous centuries clearly demonstrate. Furthermore, CT supplies three-dimensional structural information of the scanned mummified object; with these data, cross sections in any desired direction and three-dimensional models can be produced. With CT, the investigator can perform virtual endoscopy of the mummy, which allows for a journey through the unwrapped body and reveals detailed information about the mummy's sex, age, constitution, injuries, health, and mummification techniques used.

Since the 1980s, many mummies from different former cultures have undergone CT examina-

tions, and the results of individual investigations have been published (2–7). More substantial, medium-sized studies have recently expanded the knowledge of mummification and of the individual mummies themselves (8–14). For instance, an extensive and detailed description of cross-sectional features of Egyptian mummies can be found in a recently published radiologic textbook by Raven and Taconis (15), and a broad overview on features of geographic mummification is given by Arthur C. Aufderheide (16) in his textbook *The Scientific Study of Mummies*.

The aim of this article is to demonstrate the findings of CT studies performed on mummies of ancient Egypt and South America. Imaging was performed in our institute in close collaboration with anthropologic institutes, museums, and private collections in Switzerland. General background information on ancient artificial mummification is also given.

Scanning was done on a six-detector row scanner system (Emotion 6, Siemens, Erlangen, Germany) with a collimation of 0.5–1 mm with reconstructed section thicknesses of 0.625 mm and 1.25 mm, an increment of one-half the actual section thickness and soft tissue and bone reconstruction kernels. Reconstructions were performed on a regular radiologic workstation (Leonardo, Siemens).

## General Principles of Mummification

Every biologic material decays after an organism dies. Mummification characterizes the mechanisms that transform tissue into a state of decelerated or almost arrested decay. Mummification processes can be classified as “artificial,” when the procedure was performed on a corpse with the aim of preservation, or as “natural,” when the natural environment resulted in preservation of the body. The purpose of artificially mummifying human remains is to preserve that person's morphologic features for eternity. This purpose obviously necessitates the delay or arrest of certain postmortem changes.

### What Kind of Postmortem Decay Processes Need to be Arrested with Mummification?

After an individual dies, an enzymatic process called *proteolysis* begins immediately. The

enzymes that initiate the breakdown of larger proteins are set free from reservoirs in the body, such as the pancreas; this is called *autolysis* (self destruction). Later on, the bacterial flora from the intestines overgrow the tissues of the corpse. These bacteria also produce proteolytic enzymes that cause further tissue decay called *putrefaction*. Even later, maggot infestation and the growth of fungal species further destroy the tissues. All of these processes normally result in a complete disintegration of body tissues over time. The exact length of time depends enormously on the nature of the environment (eg, temperature, humidity, and local fauna) in which the body is found.

### How Can These Processes be Slowed or Almost Stopped?

There are different conditions that must be met, or that sometimes occur naturally, that can negatively influence the natural decay processes. Thermal effects (ie, heat and cooling) are the most common conditions that delay proteolysis. The aim of every refrigerator (installed in our kitchens at home and in pathologic and forensic institutions to store bodies) is to use low temperatures to slow decay. Steady temperatures below 0°C (such as those that occur in permafrost or glaciers) result in spontaneous tissue preservation in human corpses. Furthermore, exposure to heat or radiation can have a bactericide effect and can thereby slow putrefaction. This phenomenon can be observed in bodies or body parts that lie under the hot summer sun and rapidly become mummified.

Another factor that delays tissue decay and is often, but not necessarily, associated with high ambient temperatures is desiccation, or dehydration. This process withdraws from tissue the water that is needed for all biologic processes, including those involved in natural decay. Very dry regions such as the Atacama Desert in northern Chile, the Sahara Desert in Egypt, and the Gobi Desert in China have increased occurrences of natural mummification.

Aside from natural desiccation processes that occur in arid climates, mummies are also created by artificial desiccation. This method was most impressively employed by the ancient Egyptians. Knowing the hydrophilic nature of natron, also known as baking soda, they enveloped the bodies to be mummified with this naturally occurring salt for several weeks after evisceration. This pro-

cess transferred water from the body tissues to the natron, leading to artificial mummification by desiccation.

As opposed to the dry mummification mentioned above, wet and anaerobic conditions can also preserve bodies. Over a period of several months to hundreds of years, these conditions cause adipocere to form. Adipocere, which is often seen in routine forensic work on water-related deaths and is a well-known mechanism of preservation of human corpses under wet or anaerobic conditions, can preserve soft tissues for decades. The fatty acids that are released from the post-mortem metabolism of fat act as a bactericide to the bacteria involved with putrefaction and can form an insoluble soap when they are hydrolyzed from the fat conjugate with bivalent ions such as Ca<sup>++</sup>. The formation of adipocere depends on the amount of body fat present and the temperature, as well as the depth at which the body was submerged. Macromorphology of the preserved waxlike tissue can impressively persist, whereas micromorphology within the tissue can be completely decomposed (17).

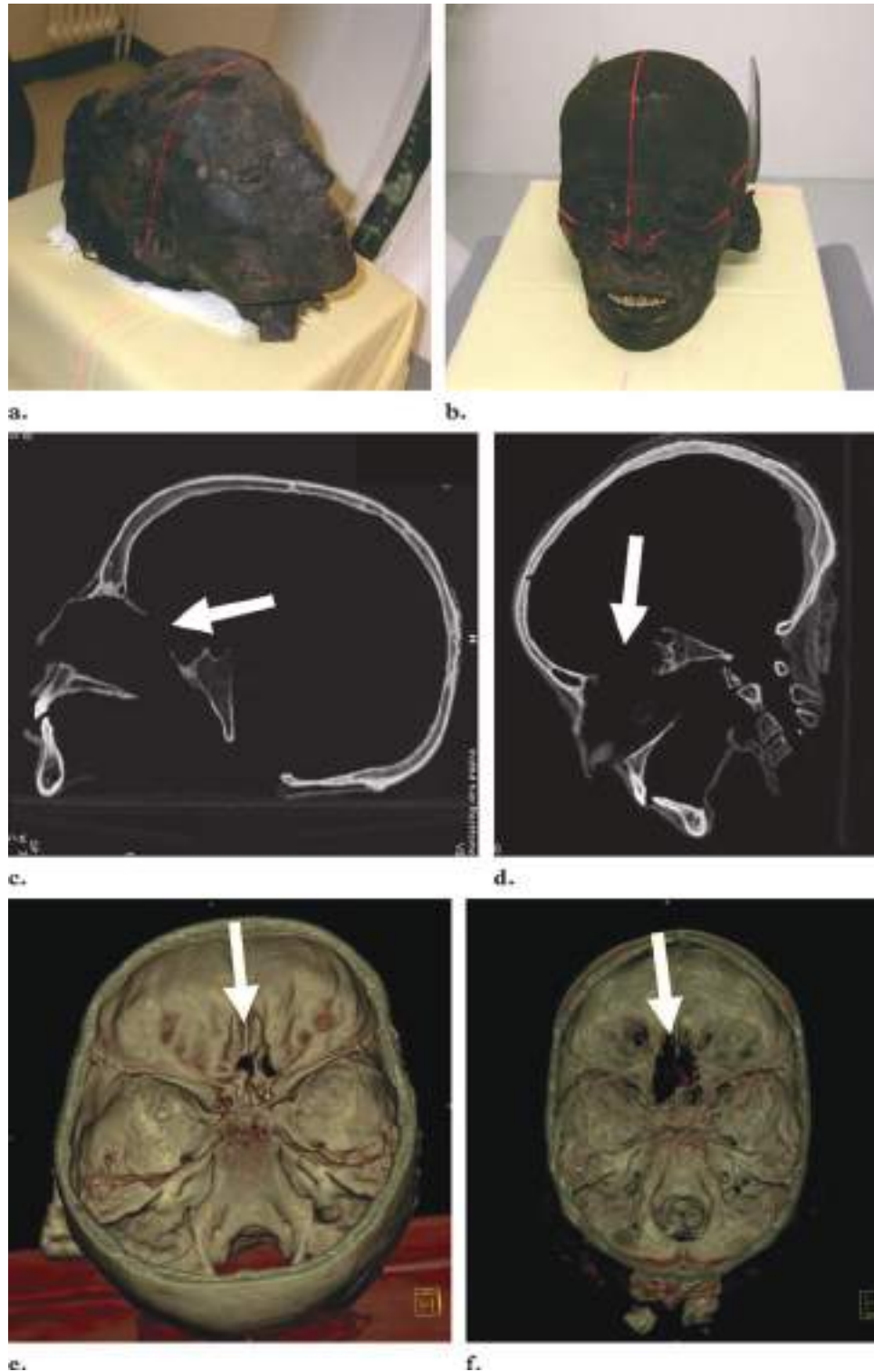
Other tissue-preserving processes include the chemical behavior of, for example, heavy metals, resins, lime, and lye, all of which also have bactericide effects.

### Egyptian Human Mummies

Mummification in ancient Egypt dates back to the Predynastic period (5500–3050 BC). The mummies that are preserved from that time mummified spontaneously and are rare. The first attempts at artificial mummification are attributed to the Archaic period (3050–2663 BC). However, the mummification techniques that are now commonly associated with Egyptian mummies started during the Old Kingdom (2663–2195 BC). The combination of evisceration followed by desiccation using natron to halt putrefaction and the use of liquid resin to prevent rehydration became such an effective form of preservation that the embalmed bodies have endured for nearly 4500 years (16).

Because the ancient Egyptians were rather reluctant to describe their procedures, few original sources of information exist. The decorations on many tombs depict the preparations necessary for

**Figure 1.** Egyptian mummies in which typical excerebration was performed. **(a, b)** Heads of female **(a)** and male **(b)** Egyptian mummies of unknown age and origin. **(c, d)** Midline sagittal reformatted CT images clearly demonstrate the defect of the cribriform plate (arrow) that occurs in a typical transnasal approach for brain removal. No brain remnants are seen within the skull. **(e, f)** Oblique craniocaudal views, produced with volume-rendered three-dimensional reconstruction and omission of the skull-cap, show the dimensions of the defects within the anterior skull base (arrow).





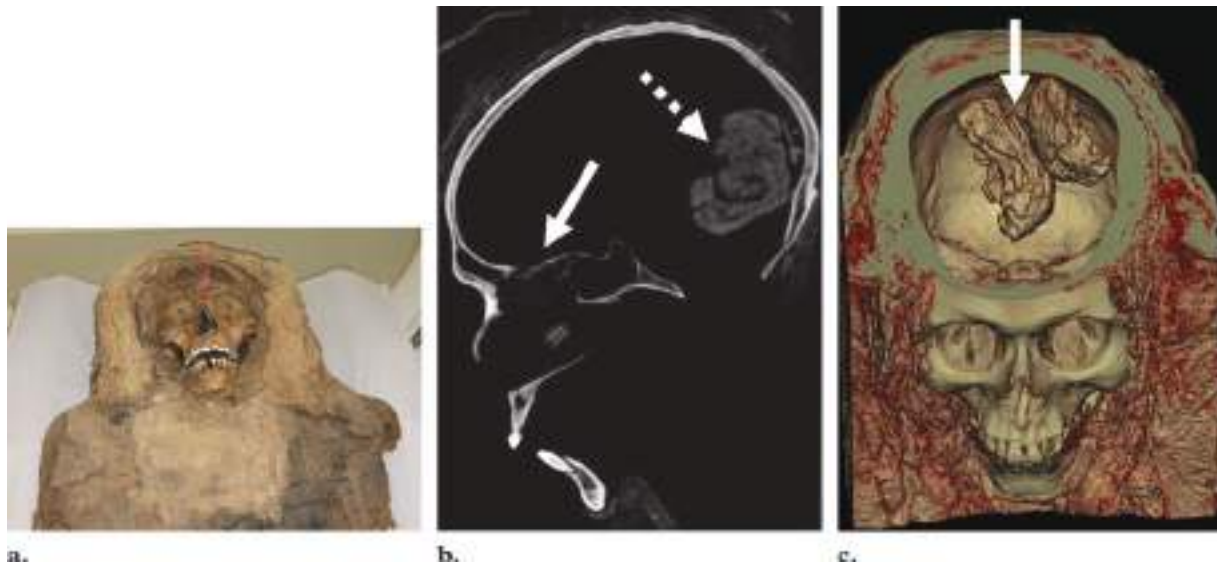
burial, but they lack details on the exact procedures and the different phases. Written information is found in several papyri dating from the Roman period, which describe a process known as the Ritual of Embalming. These papyri contained instructions for the wrapping of bodies and the insertion of amulets, among other things. Herodotus wrote the first detailed description of mummification in the 5th century BC. He described various mummification procedures and outlined three classes of evisceration and burial according to price (18,19).

**Figure 2.** Egyptian mummy with an unusual finding related to brain removal. **(a)** Sagittal reformatted CT image near the midline shows a long foreign structure of low attenuation stuck in the sphenoid sinus of a male Egyptian mummy whose age and origin were initially unknown. Excerebration had been performed, but the defect of the cribriform plate was located more to the left and is not seen on this image, which is oriented along the foreign body. **(b, c)** Extraction of the foreign body **(b)** revealed some piece of a wooden stick **(c)**. (Scale is in millimeters.) The piece of wood could have been inserted after the mummy was unwrapped during an earlier unknown investigation. The wood was radiocarbon dated and proved to be approximately 2200 years old (dating from 388–196 BC). Thus, the wooden stick was more likely related to the excerebration procedure that occurred during mummification. Taking the age of the wood into account, it is also likely that the mummy belongs to the Roman or Ptolemaic period.

The significance of mummification lies in the preservation of the body so that the soul can recognize and reunite with it in the afterlife. Artificial mummification was initially reserved for the pharaoh and his nobles, but eventually the practice spread and was used for other individuals. The process of artificial mummification is generally summarized as follows (15,16).

1. The body, with the clothes removed, was laid out on a wooden table and was washed with a natron solution. This washing was performed in a temporary structure near a source of water, such as the Nile River or a canal. Apart from its practical issues, the cleaning of the corpse had an important ritualistic meaning.

2. The embalmers then removed most of the internal organs, knowing that decomposition starts therein, and thereby prevented early disintegration of the body. The brain was often removed by perforating the cribriform plate (Fig 1) via the nostrils. Usually only one nostril was used, but sometimes this procedure was executed in a rather crude manner, which severely damaged adjacent anatomic structures such as the conchae, the orbital wall, and ethmoid cells. Long metallic or wooden hooks were advanced through the nose and cribriform plate into the cranial cavity (Fig 2). The brain was most probably removed by



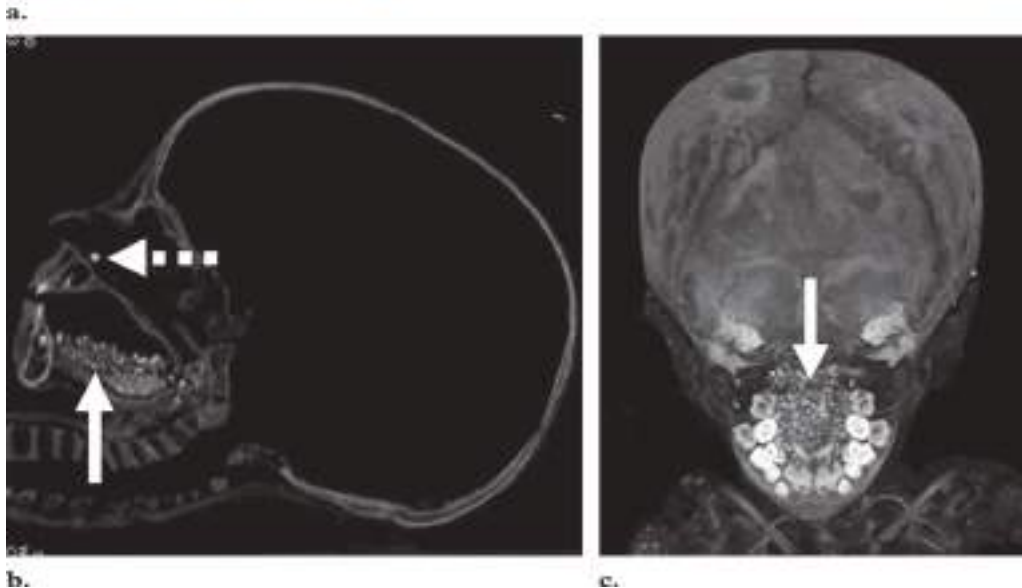
**Figure 3.** Egyptian mummy in which no excerebration was performed. **(a)** Photograph of the cranial part of a partially unwrapped Egyptian mummy of unknown age and origin. **(b)** Sagittal reformatted CT image shows that the anterior base of the skull is intact (solid arrow). Remnants of the brain are seen within the skull (dashed arrow). **(c)** Volume-rendered three-dimensional image with the skullcap removed reveals that both hemispheres of the brain are shrunken within the dorsal region of the skull (arrow).

rinsing the macerated brain out of the cranium via the bony defect that was created. The removed brain was then often discarded because it was considered irrelevant to the individual's afterlife. Afterward, the skull was rinsed with fluids; the dura and the falx often remained within the skull. Then the empty skull was packed with sheets of linen, sand, mud, or resin, or it was simply left empty. An alternative and decidedly less-utilized method of brain removal was to enlarge an approach through the foramen magnum at the base of the skull (16). In some Egyptian mummies, the brain was not removed at all (Fig 3).

3. The thoracic and abdominal organs were removed by creating a short incision in the left side of the abdomen. The kidneys, heart, and great vessels usually were left inside the corpse because it is the intestines that are mainly responsible for rapid putrefaction. An alternative way to extract these viscera was to inject dissolving fluids into the rectum and then to extrude the mixture back out through the rectum.

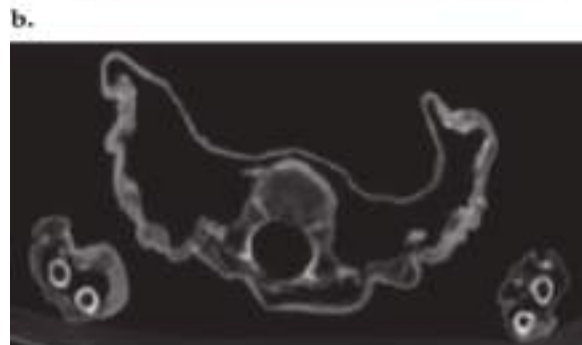
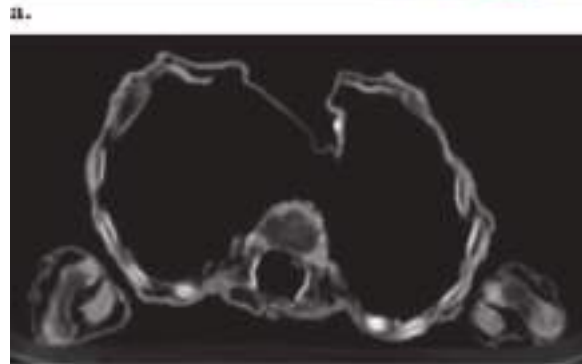
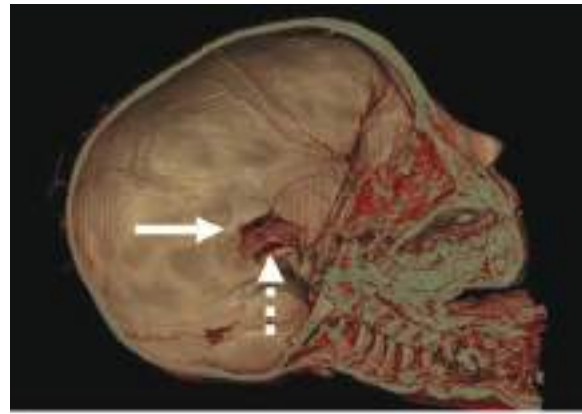
4. The empty body, as well as the removed organs, were rinsed with water and occasionally treated with spices thought to have a sterilizing effect. The organs were divided into four groups (the lungs, liver, stomach, and intestines) and were embalmed separately. They were then either stored in special containers called canopic jars or were packaged and placed back into the body cavities after embalming was done. To ensure that these organs could be used in the afterlife, their safety was entrusted to the Sons of Horus, each of whom was responsible for one organ: Imsety, the human-headed protector of the liver; Hapy, the baboon-headed protector of the lungs; Duamutef, the jackal-headed protector of the stomach; and Qebhsenuf, the falcon-headed protector of the intestines. The lids of the canopic jars represented one of these deities and gave clues to the jars' contents.

5. The most important, and probably the most lengthy, phase of mummification was desiccating or dehydrating the body with natron, a compound of sodium salts such as sodium carbonate, bicarbonate, sulfate, or chloride (Figs 4, 5).



**Figure 4.** Egyptian infant mummy. **(a)** Photographs of an unwrapped Egyptian mummy of an approximately 8-month-old girl from the Roman period (radiocarbon dated at AD 18–134) show the reddish henna color that is typical of the Roman period, as well as remnants of the wrapping on the right eyelid. It is unknown when the body was unwrapped. The mummy was originally covered with gold dust. **(b)** Sagittal reformatted CT image demonstrates plenty of coarse-grained material within the oral cavity (solid arrow). Some of these granular particles were also found within the nasal cavity, thorax, and abdomen. One particle (dashed arrow) was extracted with imaging guidance and was subsequently analyzed. It consisted predominantly of crystalline sodium chloride and therefore is probably related to the process of desiccation. The presence of sodium chloride in the body protects the mummy from rehydration. **(c)** Slight oblique craniocaudal maximum intensity projection (MIP) view demonstrates the amount of sodium chloride found inside the mummy's mouth (arrow).

**Figure 5.** Unusual mummification features in an Egyptian infant mummy from the Roman period. **(a)** Volume-rendered three-dimensional image shows an empty skull, with a completely intact skull base. In contrast to the well-known transnasal approach and the less common approach through the foramen magnum, the approach for excerebration in this case was performed by creating an artificial hole in the skull directly behind the left ear and near the pars petrosus of the temporal bone (solid arrow). Because this bony defect shows no signs of callus formation, it can clearly be identified as a postmortem lesion. The skin incision was not seen at external inspection because the henna dye stuck the hair to the skin. From the inside, the skin incision is obvious (dashed arrow). **(b, c)** Axial CT images demonstrate an empty thorax **(b)** and an empty abdomen **(c)**. No abdominal incision was detected.



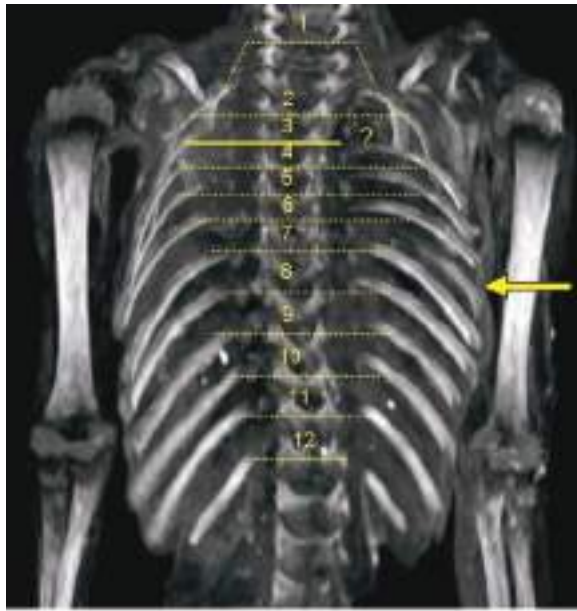
Natron is white to colorless when pure, and it varies from gray to yellow when impure. Natron deposits occur naturally in saline lakebeds in arid environments, such as Egypt. It was usually applied to the corpse in packages of linen that were stuffed in the body cavities. The entire body surface was also covered with natron. Zimmerman et al (20) carried out an experimental artificial mummification on a human body under circumstances adapted to those in ancient Egypt. They explained that 273 kg of Egypt's natron was not enough to completely dehydrate an eviscerated human body weighing 70.9 kg, although the body weight was reduced to 35.9 kg and several body parts were preserved very well during the desiccation, which lasted for 35 days. Herodotus noted that dehydration took about 40 days.

6. After dehydration was complete, the muscles and subcutaneous fatty tissue were almost completely gone, leaving only a bony skeleton covered with a thin, wrinkled skin. The body cavities were then rinsed and packed with filling material to remodel the body's former shape, or they were simply left empty (Fig 6). The different kinds of filling material used included mud, sheets, sand, rolls of linen, resin, and occasionally the visceral packages that were assembled after evisceration. The body was then prepared with all

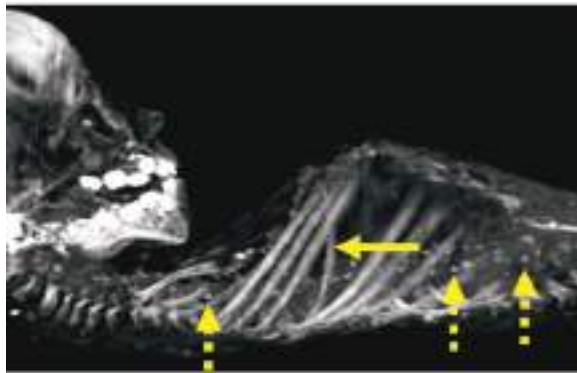
kinds of oils, aromatic resins, unguents, and perfumes. Liquefied resin was spread over the entire body to prevent rehydration. The physical appearance of the deceased was then reconstructed by arranging the hair, inserting artificial eyes, or applying subcutaneous packing material.

7. The last phase of mummification was wrapping the body. Aside from maintaining the integrity of the corpse, wrapping had a mainly religious meaning. Fine linen was predominantly





a.



b.

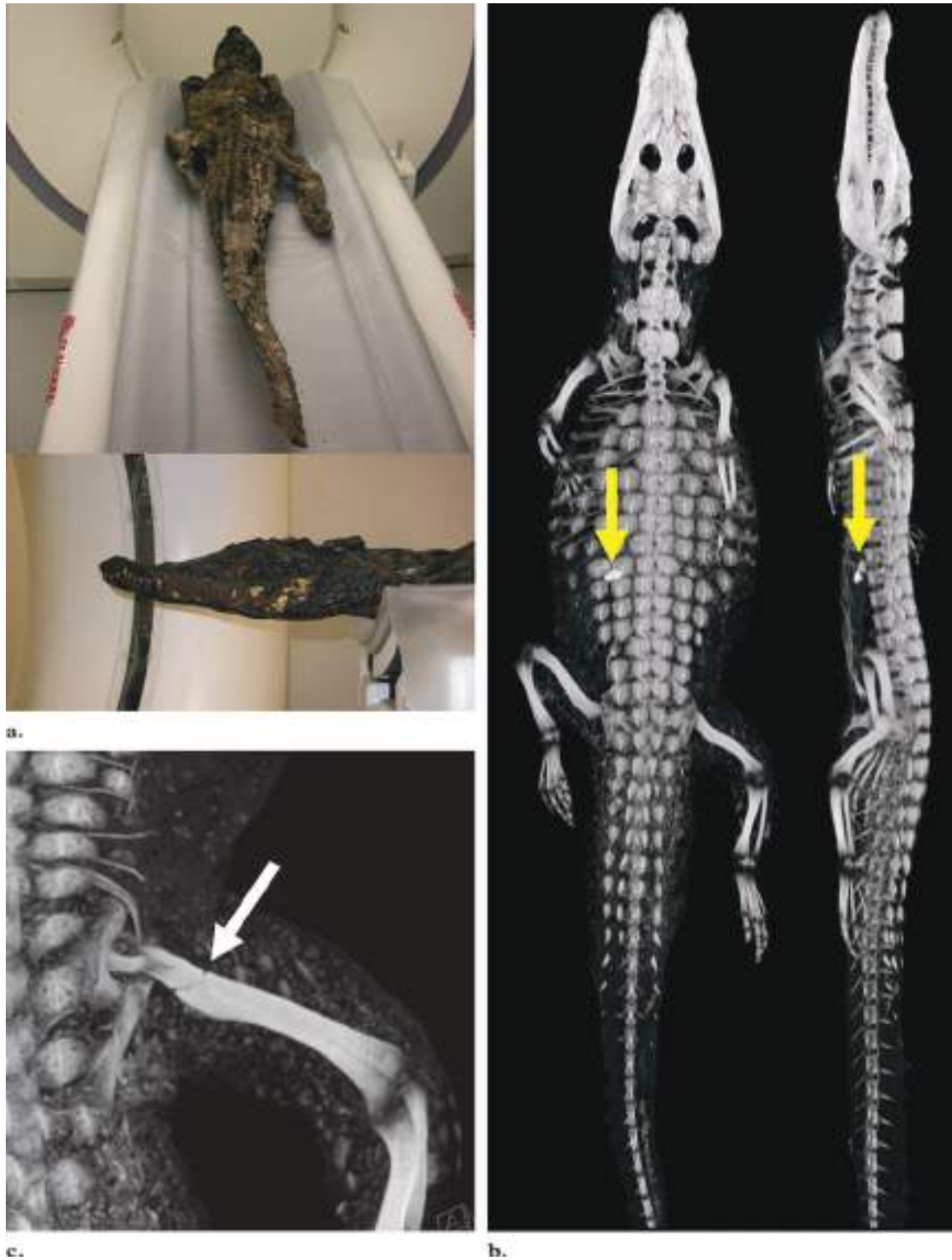
used for royal mummies, and everyday material was used for the deceased of lower social standing. The number of wrappings used and the length and thickness of the bandages varied. Usually, the head and extremities were wrapped separately. The bandages followed; they mostly followed the known spiral course. A shroud was then placed on the wrapped mummy. Various jewelry and funerary amulets were also placed on the body or between the wrappings. Herodotus reported that the wrapping and preparation for entombment were considered to take the second half of the 70-day funerary period.

**Figure 6.** Unusual mummification features in an Egyptian infant mummy. **(a)** Posteroanterior MIP view of the thorax reveals a missing third rib on the right side. The sixth and seventh ribs are straddled, and between them, another rib is seen in a more horizontal position (arrow). This is most likely the missing third rib, which was placed in this position by the embalmer. **(b)** Lateral MIP view demonstrates how the displaced rib (solid arrow) prevented the thorax from collapsing like the abdomen did. Numerous particles of sodium chloride are seen within the trunk (dashed arrows). No cutaneous incision was found at radiologic examination. External inspection also failed to reveal an incision; the incision is probably located somewhere within one of the many skin folds on the thorax.

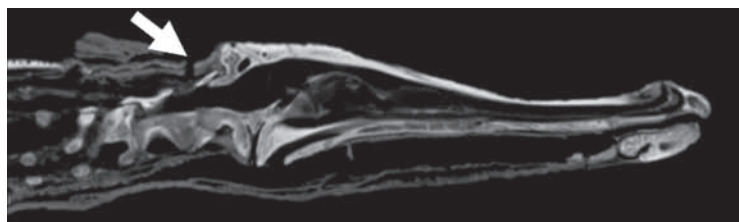
This description is only a brief summary of mummification in ancient Egypt and does not claim to be all-embracing. Furthermore, in different periods of Egyptian history, the techniques and materials used varied to some extent. Experienced Egyptologists use the knowledge of these differences in technique to relate a mummy to a specific period (16).

### Egyptian Animal Mummies

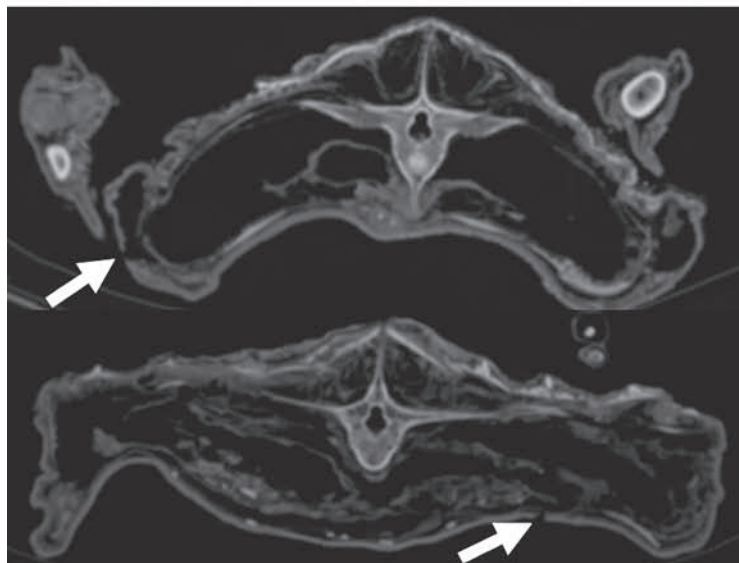
There are four different categories of animal mummies that can be distinguished in Egypt's history: *(a)* animals that were preserved as food for the deceased person; *(b)* animals that were to accompany the deceased as pets, which was quite rare; *(c)* animals that were seen as corporal manifestations of certain deities and were allowed to die a natural death and were later embalmed; and *(d)* votive offerings that were donated by devotees or pilgrims. These animals were commercially bred for this purpose and were killed before being embalmed. They included a wide variety of animals such as dogs, cats, crocodiles (Figs 7, 8), jackals, falcons (Fig 9), hawks, ibises, cows, sheep, snakes, and fish. This early commercialization also resulted in the creation of fake mummies that consisted of wrappings with either no animal remains or only loose bones, feathers, and tatters bundled up to look like the requested animal. Radiologic investigation can



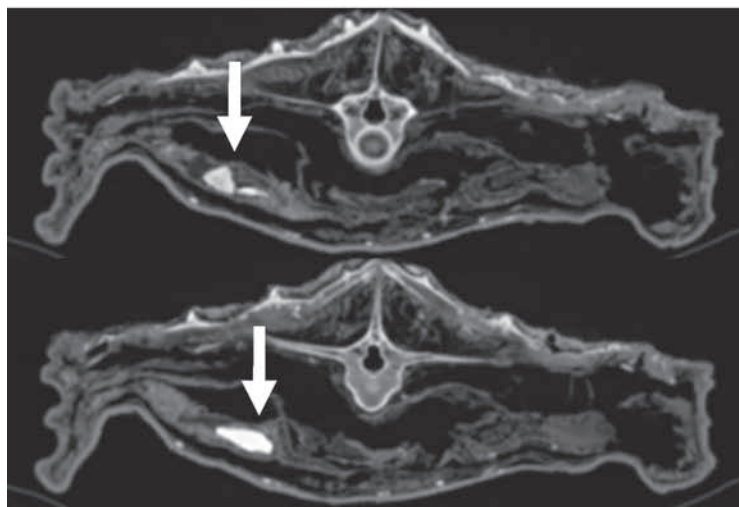
**Figure 7.** Egyptian crocodile mummy. (a) Photographs of an unwrapped crocodile mummy of unknown age and origin. (b) Posteroanterior and sagittal MIP views show the crocodile's skeleton and hornback skin with its scale pattern. Arrows indicate foreign material. (c) Close-up view reveals a fracture of the right hind leg (arrow). Since no callus formation is seen, the fracture most likely occurred either shortly before or after death.



a.



b.



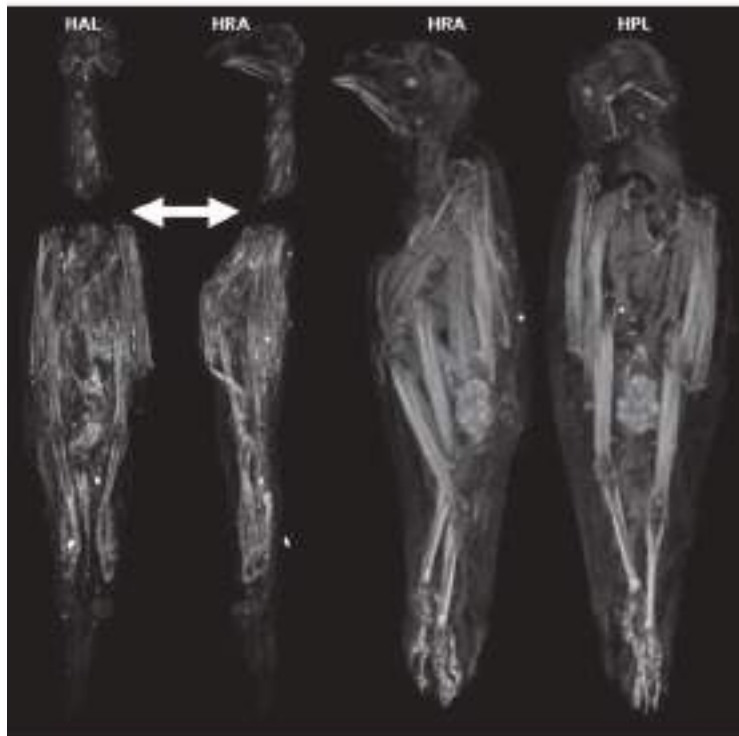
c.

**Figure 8.** Egyptian crocodile mummy. **(a)** Sagittal reformatted CT image demonstrates a broad incision in the crocodile's skull (arrow). This is most likely the site that ancient embalmers used to access and remove the reptile's brain. **(b)** On axial CT images, several holes through the entire abdominal wall are seen (arrows), predominantly on the lateral and ventral skin. Near these holes, much less abdominal content is seen, although plenty can be found throughout the reptile's entire trunk. It appears that using this minimally invasive approach for evisceration resulted in an incomplete removal of the intestines. **(c)** Axial CT images at the level of the foreign bodies (cf Fig 7b) demonstrate two irregularly formed structures of increased attenuation (1500 HU and 1900 HU, respectively; arrows). The objects appear to have been ingested by the crocodile. This is a normal finding; crocodiles often swallow stones to counter buoyancy.

**Figure 9.** Egyptian bird mummies. **(a)** Photographs of an Egyptian mummified bird. Because of the commercialization of mummification in ancient Egypt, there was a market for fake mummies that contained no actual mummified animals. Because the shape of a mummified bird bundle could easily be created with less “expensive” content, it is important to separate genuine mummified birds from false ones, especially in bird bundles. **(b)** CT scan of two bird bundles reveals that they contain real mummified birds (most likely a falcon and some kind of small seed predator). Note that the head is detached in one bundle (double-headed arrow). All the mummified birds we examined with CT turned out to be real.



a.



b.

easily separate real mummies from fake ones and can verify the authenticity of any animal bundle (Fig 9).

Various methods of animal mummification were practiced until Christianity spread during the 4th century AD. For example, some animal mummies were shaped to look like human mummies (eg, birds or cats were made to look like children). Others remained in their shape as a bundle. One of the largest collections of mummified animals can be seen in the Egyptian Museum in Cairo. These animals were scientifically investigated in the Animal Mummy Project (21). In this study, researchers performed a visual examination of both wrapped and unwrapped mummies, made zoologic classifications if possible, performed x-ray examinations, and photographically documented the mummies. Age and cause of death were studied as far as possible, and the wrappings were described.

### South American Mummies

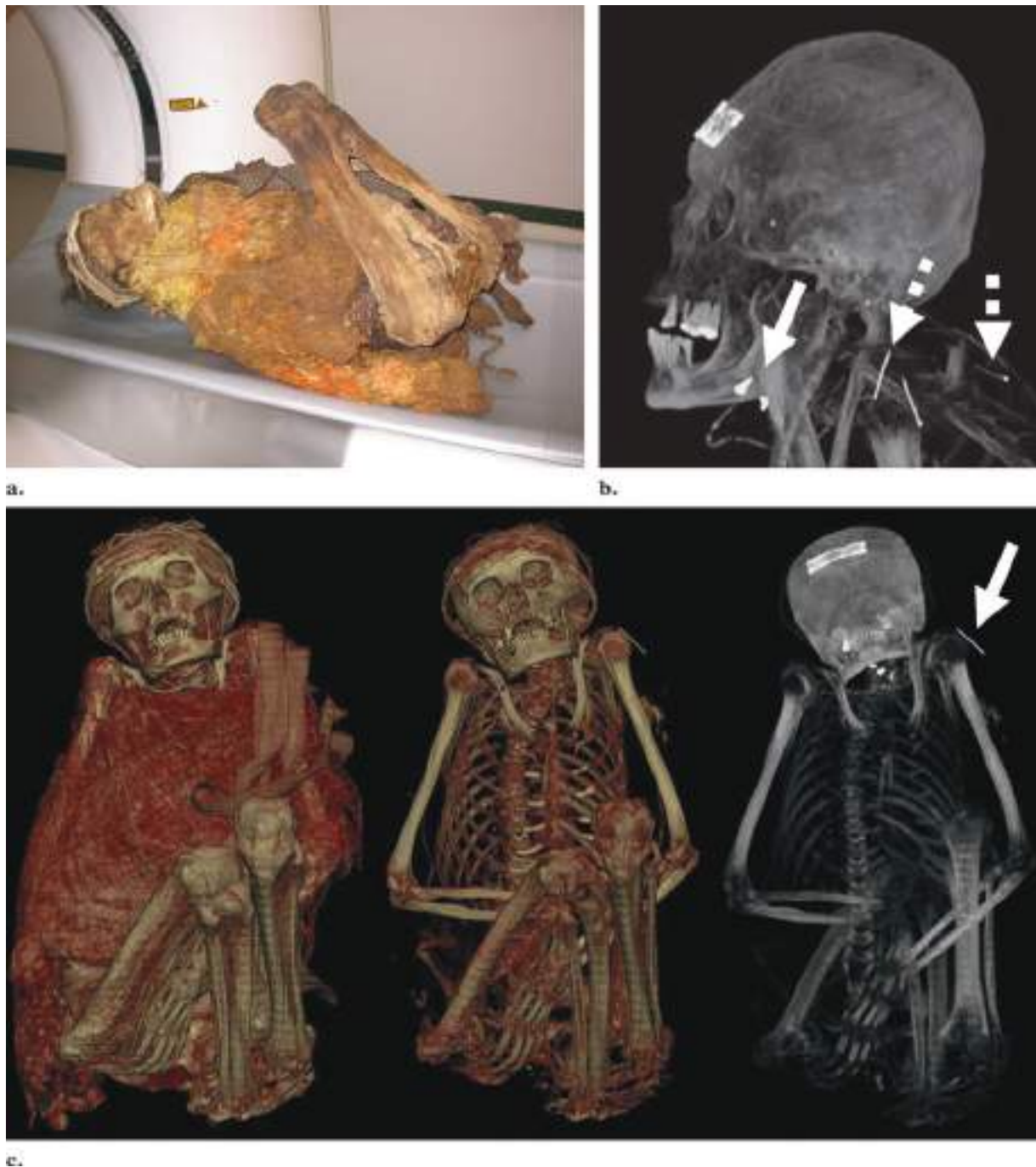
Artificial mummification was not only performed by the well-known embalmers of ancient Egypt. Human mummies of comparable preservation quality have been found on almost every continent (16). South and Central American tribes left a large number of mummies in what is now Mexico, Chile, Peru, Ecuador, and Colombia from 1800 BC to AD 1500. However, in South America, mummification started far earlier. Roughly 7000 years ago, 2000 years before the Egyptians began artificial mummification, a small Andean tribe known as the Chinchorros began to embalm its dead by using elaborate preparatory processes. Although some naturally occurring mummies (dried by the hot climate of the Atacama Desert in Chile) have been associated with the Chinchorros, archaeologists have discovered many artificially preserved Chinchorros mummies. The oldest date to earlier than 5000 BC.

The techniques of Chinchorros mummification largely involved preserving the skeleton of

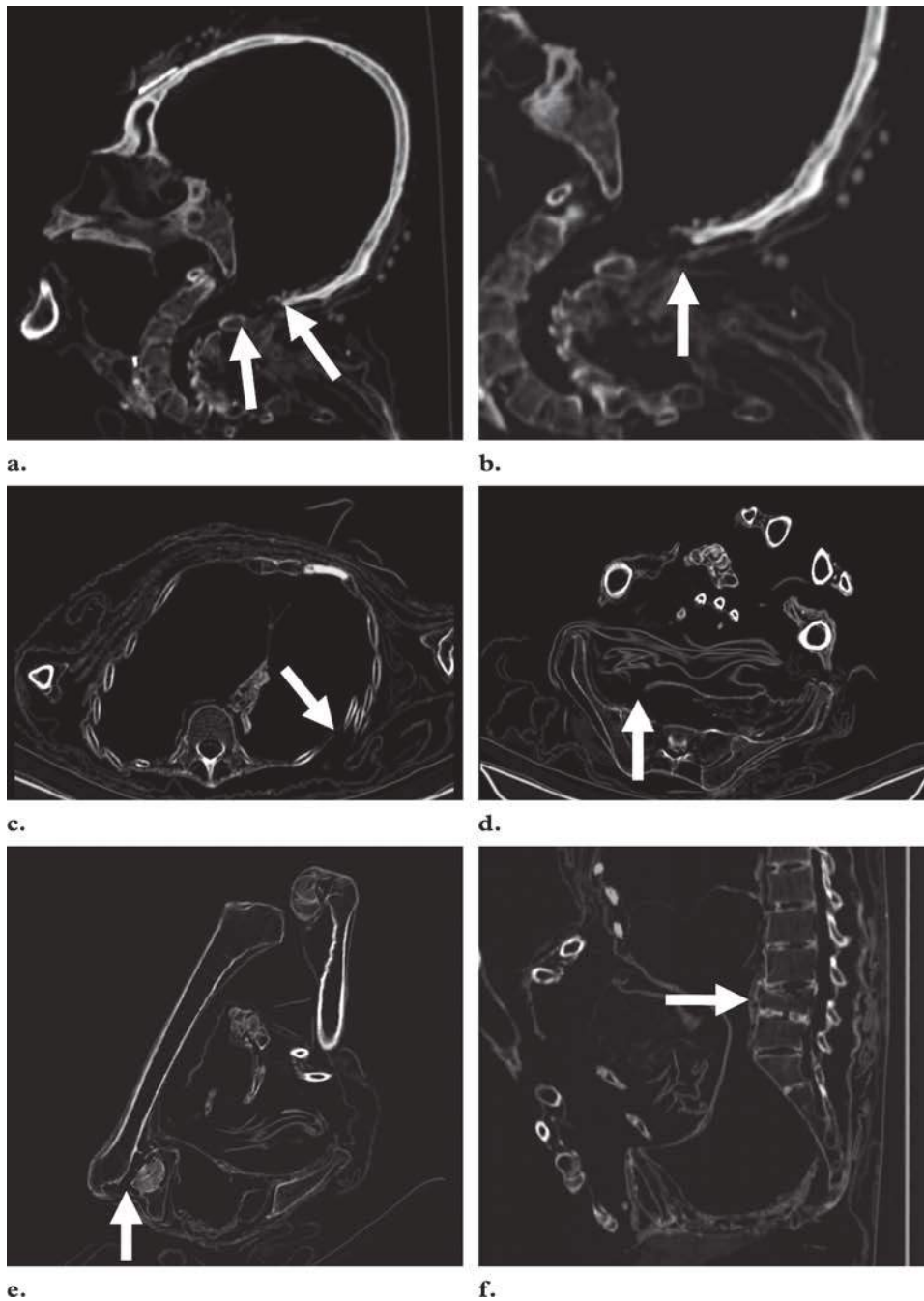
a deceased tribe member and “rebuilding” the individual by ritually applying natural materials as well as sculpted clay fixtures and adornments. Perhaps most strikingly, the Chinchorros painted a large number of mummies with red or black colors or with simple mud. The progression of these coloration techniques has been helpful in tracking the timeline of Chinchorros mummification practices.

One of the differences between Chinchorros mummification and that of ancient Egypt is the broad spectrum of society that is represented by its mummies. Virtually every member of the tribe was eligible for mummification, including stillborn children. Egyptian mummification was largely an expensive, status-based privilege reserved for nobles, but Chinchorros mummification was for everyone. Anthropologists believe that mummification was part of the Chinchorros’ worship of their ancestors. However, the tribe’s use of mummification died out in the 1st century BC. Other tribes, such as the Incas, continued to practice mummification until the Spanish conquest of South America in the late 1500s and early 1600s.

Most later South American mummies had flexed extremities and were buried in so-called bundles in some kind of crouching fetal or embryo position (Fig 10). Evisceration was not as widespread as it was in ancient Egypt, but it was performed occasionally (Fig 11). Tissue preservation achieved astonishing results. Surviving examples of the ritual mortuary practices of the Chinchorros and other tribes show that South America should be recognized as the true motherland of artificial human mummification. The practice began much earlier and lasted much longer than the more famous Egyptian mummification.



**Figure 10.** South American mummy. **(a)** Photograph of a mummified young man from the highlands of the Andes. Flexed extremities are typical of South and Central American mummies because most of them were buried in a kind of sitting position. **(b)** Lateral CT image of the mummy's head shows the deformation of the cranium. Several tribes along the Andes marked individuals by deforming their heads so that they could be identified as members of a certain group. This deformation was achieved by placing a textile band around the head during early childhood and continually tightening it during the first 2 years of life. The band was usually removed before the child's third birthday. Note also the postmortem loss of two teeth that remain in the oral cavity (solid arrow). Dashed arrows indicate needles that were used to fix the colored fur in which the mummy was wrapped. **(c)** Volume-rendered three-dimensional views, which demonstrate virtual removal of the wrapping, give an overview of the skeleton. Again, note the needle used for fixing the fur wrapping (arrow).



**Figure 11.** South American mummy of a young man. **(a)** Slightly oblique sagittal reformatted CT image shows an empty skull. No lesion was found on the skull base; however, the space between the posterior arch of the atlas and the posterior edge of the foramen magnum is distinctly enlarged (arrows). **(b)** Magnified view of **a** reveals a skin incision in the back of the upper neck (arrow); excerebration was most likely performed through the foramen magnum. **(c)** Axial CT image through the thorax reveals an incision through the left side with displaced ribs (arrow). Because the thorax is empty except for a few remnants of mediastinal structures, this incision appears to be the approach used to reach the thoracic cavity. **(d)** Axial CT image through the abdomen reveals an incision on the right side through which the intestines were removed (arrow). **(e)** CT image shows a vital fracture of the right femoral neck (arrow). The distinctive transformation at the edges of the fracture indicates that this incident must have occurred recently before the man died. **(f)** Sagittal reformatted CT image reveals another fracture of the fourth lumbar vertebral body. Both fractures may be related to a single incident (eg, a fall from a great height in which he landed on his feet) from which the man survived for at least several days.

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