Egyptian Journal of Archaeological and Restoration Studies (*EJARS*)
An international peer-reviewed journal published bi-annually
www.ejars.sohag-univ.edu.eg

Original article

NEW READING USING NON-DESTRUCTIVE CT ANALYSIS FOR EVALUATION OF THE ANCIENT EGYPTIAN MUMMIFICATION TECHNIQUE APPLIED TO THE MUMMY OF TJANEFER, DYNASTY 21, 3RD INTERMEDIATE PERIOD.

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Article info.

Article history:

Received: 11-4-2023
Accepted: 18-5-2024
Doi: 10.21608/ejars.2024.361165

Keywords:

Mummification
Subcutaneous packing
CT Scanning
Tjanefer
3rd Intermediate Period
wax figurines

EJARS – Vol. 14 (1) – June. 2024: 19-27

Abstract:

The study of ancient Egyptian mummies is of great interest to scientists and the public in general. Recent research highlights the need for a new reading of the science of mummification using the latest scientific methods of examination such as CT scanning. In the last forty years, many non-destructive CT scanning studies of Egyptian mummies from different museums and collections in Egypt, Europe, and the USA have been conducted, proving to be powerful tools in current research studies of ancient Egyptian human remains. CT scanning can identify which type of embalming techniques were used to preserve each mummy and have revealed that ancient Egyptian embalmers used methods to maintain the external shape of the mummy by inserting filler material under the skin during the 3rd Intermediate period. The main aim of this research is to thoroughly study Tjanefer, a mummy of the 3rd Intermediate period, to demonstrate the level of sophistication of the mummification technique reached during this period.

1. Introduction

The 3rd Intermediate Period (1100-650 BC) is considered a distinctive period in ancient Egyptian history. While the term "Intermediate" is used to describe the political decline during this period, it does not reflect the cultural development that continued under separate regional administrations. The mummies discovered dating back to this period demonstrate the combined economic, cultural, and scientific growth that distinguished this era throughout Egyptian history [1]. The science of mummification progressed through various developmental phases since establishment during the predynastic period (5500-3050 BCE), based on historical transformations which occurred during each Egyptian era. The development proceeded at a slow pace, depending on the quality of the materials available, the precision of the tools used, and the ingenuity of the embalmer. When studying mummification, it is difficult to classify mummies into one specific framework. Rather, each mummy is a distinct case, depending on the deceased's status, the body's condition, the embalmer's skill, the materials, and tools used in embalming, and the method followed by the embalmer according to their vision regarding the outcome of the external shape of the mummy [2]. The development of embalming in the 3rd Intermediate Period resulted from the fusion of economic and cultural aspects of the era, medical science, pharmacology, and the knowledge of anatomy known at the time. Historically scholars have observed these methods, but the means and methods used in recording and documenting the mummification phases had been meager. However, by the end of the 20th century, methods of examination and analysis of mummies were being completed through CT scanning and ancient DNA analysis [3]. During the 3rd Intermediate Period, embalmers

introduced unique concepts to the mummification process. Seeking perfection by preserving the shape of the external body, embalmers inserted various materials under the skin to maintain the original contours of the mummy after dehydration with natron salts. Examination by CT scanning provides a comprehensive analysis of the various mummification methods used by ancient Egyptian embalmers The aim of this study, CT scanning was used to examine the mummy of Tjanefer, dating to the 21st dynasty, 3rd Intermediate period.

1.1. *Evolution of mummification techniques during ancient Egyptian eras*

Mummification techniques have undergone significant changes since the pre-dynastic era of natural mummification. This development was gradual and based on the evolution of both religious and medical concepts. During the *predynastic era*, the main element of (natural) mummification resulted from the arid climate conditions of the burial and the dehydrating effect of the dry sandy soil on the body [4]. During the *Old Kingdom*, the use of a solution of natron salt in liquid form to dehydrate the body before burial was initiated [5]. However, this technique often resulted in deterioration of different parts of the body particularly the face, arms, and legs, and sometimes even the separation of parts of the body from each other. The belief that the soul would be unable to recognize the body in this deteriorated state, linen wraps dipped in resin were introduced to reform the parts of the body that were lost following use of natron salts in liquid form. The process of wrapping the body in layers of linen dipped in resin encased the mummy like a "coffin" in the advanced times of the Old Kingdom. Taylor believed that this was the beginning of the necessity of using wooden coffins for the burial of the deceased [6]. Ultimately, this resulted in the production of several burial coffins for each mummy. For example, the two coffins of Meresankh in the Egyptian Museum [7] and the mummy of Ra-Nefer at the British Museum, which was subsequently destroyed in 1941 during World War II [8]. By the *Middle Kingdom*, the ancient Egyptians used natron in its solid form to dehydrate the bodies of the deceased, initiating the beginning of ideal artificial mummification [9]. Mummification was not restricted to the royal class during the Middle Kingdom but included senior officials and priests. Internal organs were not removed (excerebration/evisceration) during the Middle Kingdom. Instead, the embalmer injected orifices (anus) with oils, such as cedar oil or juniper oil, which was imported and very expensive, to cleanse the bowel of putrefying organisms. Other times, they used radish oil as one of the locally prepared ingredients with a similar effect as with cedar or juniper oil [10]. During the Middle Kingdom, mummies were found to be well-preserved, without excerebration or evisceration, and wrapped in linen [11]. In the *New Kingdom*, there was a notable development of surgical intervention applied to the deceased's body before the use of solid natron salt. First, the brain was removed through an opening made by the embalmer through the ethmoid bone of the skull [12]. Then, a ventral incision was made in the left side of the abdomen thru which the embalmer removed the lungs, liver, stomach, and intestines. After being dried using natron salt, these organs were then wrapped in linen and stored in Canopic jars [13]. The heart was usually left in place. During this period, for preservation the embalmer was very interested in isolating the body from the surrounding climate using different types of oils and resins on both the interior and exterior of the deceased's body [14]. Isolation from the surrounding climate became the backbone of the mummification process during this era, which was followed by wrapping the body in multiple layers of linen dipped in molten resin [15]. Some mummies had white sand added to the linen wrappings to support the body in addition to the isolation techniques, although the most important characteristic of mummification during the New Kingdom was primarily isolation [16]. By the 3rd Intermediate Period, mummification had reached its greatest phase of development and splendor. The embalmer had full knowledge regarding the ideal method of preserving the internal organs by removing; drying, wrapping, and placing them back into the abdominal and thoracic cavities [17]. Canopic jars were no longer used to store the internal organs as the preserved organs were returned to the body before wrapping the mummy during this era. Through the CT examination of many third intermediate period mummies, it was determined that isolation from the environment and preservation of the organs was well established. In addition, arteries and veins of the body were well-preserved [18]. Dehydration using natron salt caused loss of subcutaneous fat and muscle shrinkage, so the embalmer restored the shape of the body through subcutaneous injections with fillers of fine linen soaked in resin and white sand [19]. The external shape of the body was restored according to the form that the deceased had during life [20]. Evidence of use of subcutaneous fillers has been documented by CT examination of mummies during this period.

1.2. *Historical background*

The Mummy of Tjanefer, no: TR 28.4.26.13(a), 3rd Intermediate Period, 21st dynasty, was discovered in 1891 in the Bab el-Gasus Cache at Deir el-Bahri in Thebes. Tjanefer was an ancient Egyptian priest of Amun. His father, Nesipaherenmut, was the Fourth Prophet of Amun, and his mother was Isetemkheb, fig. (1). According to the Karnak priestly annals, [21] Tjanefer served as the Fourth Prophet of Amun in the 40th regnal year of Psusennes I (c. 1008 BCE) [22]. He was later promoted to 3rd Prophet, as mentioned in a papyrus found in his tomb at Bab el-Gasus (currently at the Egyptian Museum in Cairo-Current: EMC SS136 - CG61091). Tjanefer was married to Gautsoshen, the daughter of High Priest Menkheperre and Princess Isetemkheb. They had two sons, Pinedjem, who later became the Fourth Prophet of Amun, and Menkheperre, who became the 3rd Prophet of Amun [23].

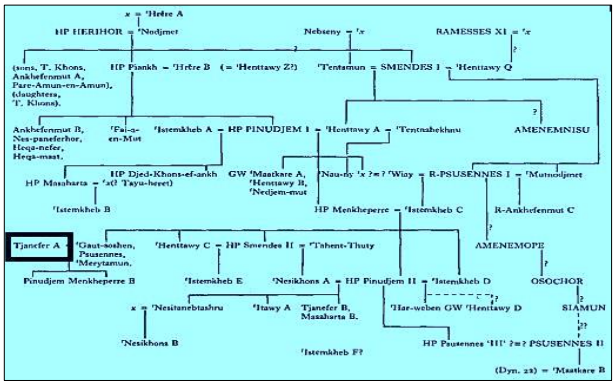


Figure (1) black rectangle refers to the position of Tjanefer in his family of the 21th dynasty, 3rd intermediate period (*After: Kitchen, 1982*).

2. Materials and Methods

Since the discovery of Tjanefer's mummy at Bab el-Gasus in 1891 and its subsequent transfer to the Kasr al-Ainy Museum at the Faculty of Medicine, Cairo University, it remained unstudied until the Horus Research Team performed a CT scan in 2009. To assess the condition of Tjanefer's mummification technique, a whole-body CT scan was performed using a Siemens Emotion 6 scanner (Florsheim, Germany), with 3D volume reconstructions software were created from the CT data located at the Egyptian Museum in Cairo, fig. (2) [24]. The CT operating conditions are shown in tab. (1).

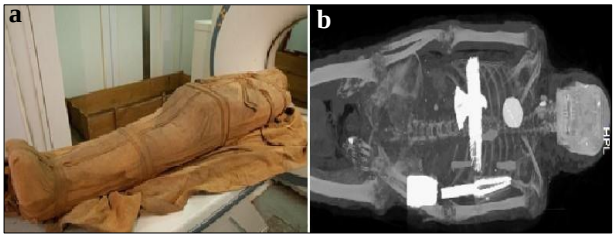


Figure (2) **a.** mummy of Tjanefer on CT scanner, **b.** CT topography of the mummy.

Table (1) Siemens emotion 6 CT scanner, system operating conditions (Egyptian Museum, Cairo)

Physician	Scan	KV	Mass/ref	CTDLvoL	DLP	TI	eSL
Pation position H-	-	130	-	-	-	-	-
Topo gram	1	130	-	-	-	11	0.5
Head	2	130	130	17.63	416	0.8	0.5
Control scan	3	130	45	9.85	1	0.8	1.0
Dental	4	130	45	12.36	148	0.8	1.0
Operation body scan	5	130	58/124	7.70	506	1.5	1.0
Add scan	6	130	79/124	10.8MAS	2463	1.5	0.5

3. Results

3.1. *CT scan findings of archaeological artifacts*

During the CT scanning of the Tjanefer mummy, numerous artifacts were discovered in one of four locations; inside the body cavity, directly on the body, between layers of linen, or under the shroud of the mummy, fig. (3).

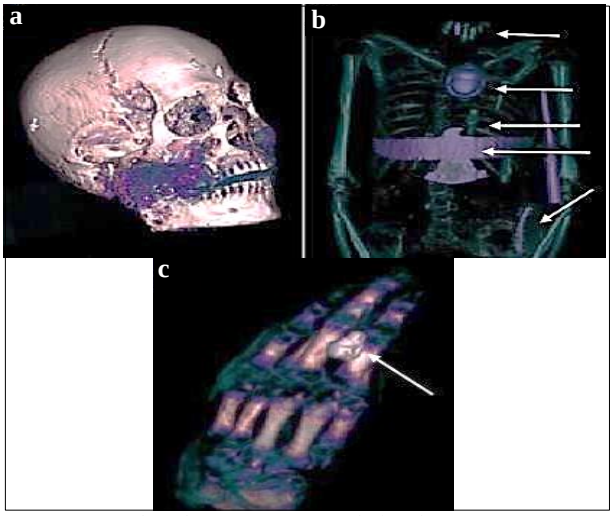


Figure (3) amulets shown on CT scan of Tjanefer's mummy; **a.** skull: djed pillar on right parietal bone, 2 small amulets on the forehead, **b.** neck and thorax: necklace, heart scarab, nehebkau plaque (under the heart scarab), winged Horus pectoral, four sons of he, **c.** scarab amulet on the proximal phalanx of the left second finger.

3.2. *Archaeological findings inside the mummy's body cavity (Figurines of the 4 sons of Horus)*

Scholars specializing in the study of the 3rd Intermediate Period have confirmed that during this era the internal organs of the mummy were embalmed outside the body and then placed back into the body, along with four figurines representing the four sons of Horus. This was discovered during destructive examination of several 3rd Intermediate Period mummies [25], as shown in fig. (4-a). In the case of Tjanefer's mummy, the sons of Horus figurines consisted of a dense core (1000 HU), representing fired-clay, encased by a low-density material (-68 HU), consistent with beeswax, which covered the entire surface of the figurine and extended beyond the figurine to form the foot base, fig. (4-b & c). The four figurines have an average dimension of (7×2×1.7cm). The four sons of Horus were named Imsety, who had a human head and protected the liver; Duamutef, who had a jackal head and protected the stomach; Hapy, who had a baboon head and protected the lungs; and Qebehsenuef, who had a falcon head and protected the intestines. These statues were usually wrapped in linen and placed inside the body cavity along with the mummified internal organs. However, in Tjanefer's mummy, the embalmer placed the figurines inside the chest cavity without the associated organs, four additional linen packets were placed in the chest and abdominal cavities which likely contain the actual mummified lungs, liver, stomach, and intestines of Tjanefer. In total, the mummy of Tjanefer had 8 linen packets placed within the body cavity, four sons of Horus packets and four separate linen packets likely containing Tjanefer's mummified organs.

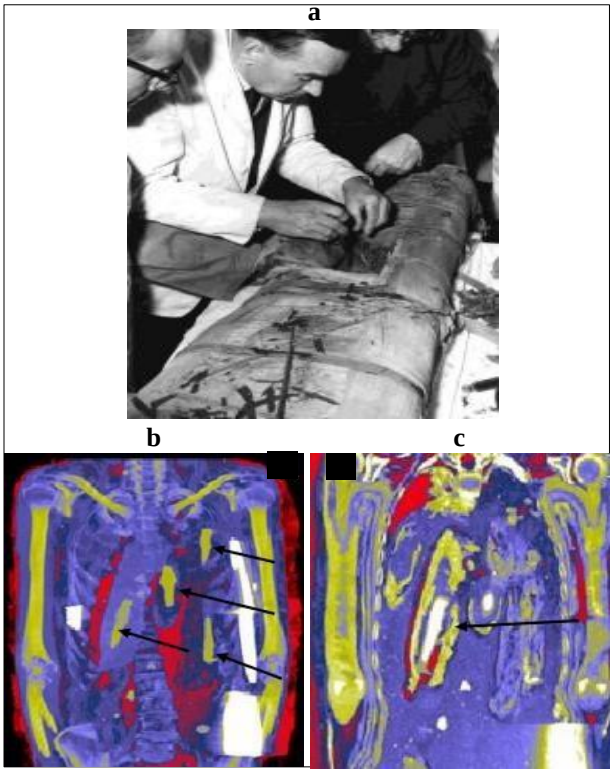


Figure (4) **a.** the extraction of wax figurines from a mummy in the 20th century during a destructive examination. From Abeer Helmy, The British Museum Trustees composite wax and fired-clay figurines of the four sons of Horus located inside the thoracic cavity of the mummy of Tjanefer; **b.** Four sons of Horus statues showing the dense core of fired-clay. **c.** a layer of wax overlaying the dense core and forming the foot plate.

3.3. *Archaeological findings between the layers of linen (Heart scarab amulet and Nehebkau plaque pendant)*

The CT images show a heart scarab amulet measuring (4× 6×4 cm) slightly to the left of midline, between the linen wrappings, resting on the chest of Tjanefer's mummy, fig. (5). The scarab (2600- 2860 HU) suggests it was made of calcium carbonate such as calcite or limestone [26]. To visualize the inscriptions on the back of the heart scarab, 3D volume reconstructions were created from the CT data. Ten lines were visible; however, the hieroglyphic inscriptions were not discernable due to technical factors of the CT scan slice thickness being greater than the thickness of the inscriptions (volume averaging), effectively rendering the inscriptions invisible as they were averaged within the CT slice, fig. (6-a). A similar heart scarab made of slate and inscribed with nine line of hieroglyphics is present on the 3rd Intermediate Period mummy of Gautsoshen, Chantress of Amun, housed at The Metropolitan Museum of Art in New York, not to be confused with Gautsoshen, wife of Tjanefer, daughter of High Priest Menkheperre and Princess Isetemkheb, housed in Cairo. In 2002, Janssen et al. conducted a CT investigation with the objective of visualizing hieroglyphic inscriptions on nine scarabs that were enclosed within wrapped mummies from the Dutch collection [27]. Surprisingly, it was discovered that all nine scarabs were completely devoid of any inscriptions. It is important to note that during the 22nd dynasty, heart scarabs were occasionally left unmarked, lacking any inscription [28]. This practice contrasted with earlier scarabs, which were typically engraved with Incantation 30b of the Book of the Dead [29]. Directly behind the heart scarab is a (3.0×1.5×0.5 cm) flat plaque pendant measuring (1130 HU) which suggests it is made of fired clay. The surface of the plaque contains a raised figure with a pointed head standing with outstretched arms holding an object, fig. (6). This appears to represent the Nehebkau snake god figure mentioned as early as the Pyramid Texts. The Nehe-bkau figure symbolizes invincible living power and became identified with Atum. The Nehebkau figure was first found in non-royal 3rd Intermediate Period burials. In the Book of the Dead, Nehebkau acted as one of the 42 Assessors of the Dead [30].

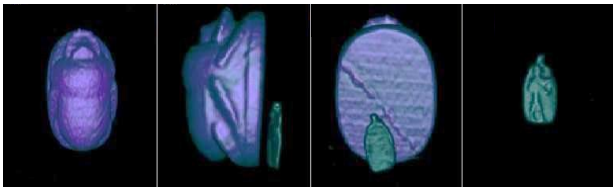


Figure (5) 3D image of the heart scarab on the chest of the mummy

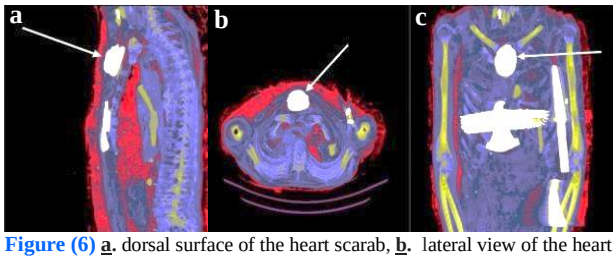


Figure (6) **a.** dorsal surface of the heart scarab, **b.** lateral view of the heart scarab (blue). snake god nehebkau plaque pendant under the heart scarab (green), **c.** posterior surface of the heart scarab with 10 lines of Inscription (blue). posterior surface of the snake god Nehebkau plaque pendant under the Heart Scarab (green).

3.4. *The archaeological findings on the mummy's body*

3.4.1. Necklace amulets

A necklace of 10 amulets was found on Tjanefer's mummy during the CT scan. The necklace is made up of 5 large and 5 small amulets. The HU densities range from 1100-2800 HU which correspond to ivory, nacre, ceramic, obsidian and fired clay [31]. Amulets 1, 2, 4, and 5 represent Djed Pillars, a commonly found symbol in anc-ient Egyptian religion. The Djed is a symbol of stability, representing the spines of the creator god Ptah and Osiris, the god of the afterlife. The HU densities suggest that the Djed pillars, in order of their position on the necklace, are made of ivory, nacre, ceramic, and obsidian. The 3rd amulet in the necklace is a Wadj or Papyrus column/scepter which is intended to ensure eternal youth in the afterlife. By HU density this Wadj is made of ceramic. The 5 small amulets with densities of 1100 HU are made of fired clay. The shapes of these 5 small amulets appear to represent figurines, fig. (7).

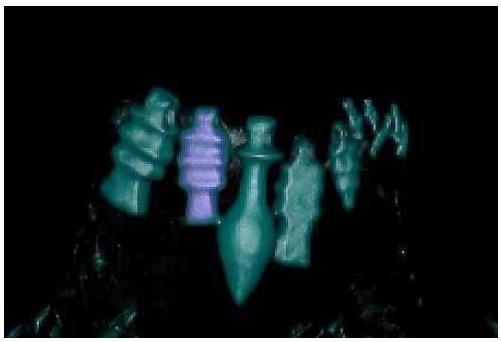


Figure (7) CT scan 3D reconstruction of the 10 amulets of the necklace, coronal plane

3.4.2. Horus falcon pectoral

Tjanefer's high religious and social status led the embalmer to place many magical amulets in or on his mummy to protect the deceased in the afterlife, perhaps the most important of which was the winged falcon god, Horus pectoral [32]. The winged falcon Horus pectoral, on the chest of Tjanefer's mummy, holds *shen* rings in his talons, symbols of the eternal circuit of the sun, fig. (3-b & 6). The pectoral measures (22×12×0.2 cm) and is of metal density (3000 HU). A similar pectoral is present on the 3rd Intermediate Period mummy of Gautsoshen, Chantress of Amun, housed at The Metropolitan Museum of Art in New York, mentioned above. Her winged Horus pectoral was made of bronze or copper alloy. The manufacturing method of the winged Horus indicates the elaboration of metal casting during the Egyptian era.

3.4.3. Wedjat eye incision plaque

Over the left-sided abdominal incision, through which the internal viscera of Tjanefer were extracted, a plaque was found incised with a wedjat eye, the eye of Horus symbolizing healing, protection, and regeneration [33]. The plaque was of high attenuation density (3071 HU) consistent with metal and measured (10.6×5×0.2 cm), fig. (8). A similar incision plaque was found on the 3rd Intermediate Period mummy of Gautsoshen, chantress of Amun, housed at The Metropolitan Museum of Art in New York, mentioned above. Gautsoshen's incision plaque was made of bronze or copper alloy.

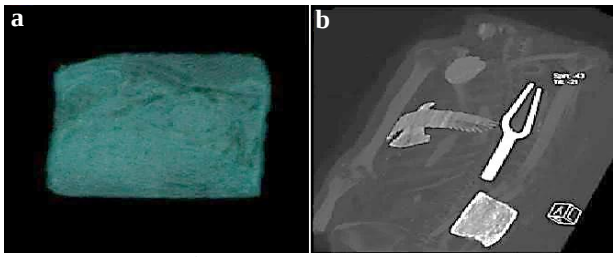


Figure (8) **a.** detail of the plaque incised with a wedjat eye, the healing eye of Horus, **b.** the location of the plaque over the left-sided abdominal incision, below the left arm. wrapping quilling tool.

3.4.4. Wrapping quilling tool.

During the CT scan examination of the mummy, a tool for quilling the linen wrappings was found on the left side of the mummy above the incision for extracting the viscera [34], next to the left arm, partially within the linen wrappings and partially beneath the shroud of the mummy. The tool has a metallic component with high attenuation density, measuring (23.5 cm in length and 2 cm in width), fig. (9). Not present in previous Egyptian eras, use of a quilling tool was prominent during the 3rd Intermediate Period, a significant indication of the level of mummification development that occurred during this period. To our knowledge, this is the first appearance of this tool in a wrapped mummy.

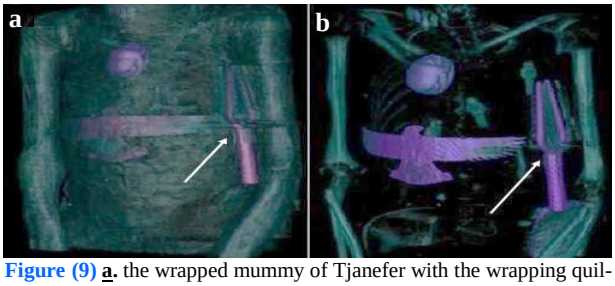


Figure (9) **a.** the wrapped mummy of Tjanefer with the wrapping quilling tool inside the shroud, next to the left arm, above the incision plaque, **b.** the artifacts after digitally removing the linen wrappings.

3.5. *CT Scan of mummification techniques of Tjanefer's mummy*

3.5.1. The skull

During the CT scan examination of Tjanefer's mummy, it was found that the ethmoid bones, cribriform plate, and a portion of the sphenoid bone were missing, creating a passage used by the embalmer for extraction of the brain. Remnants of the falx and dura are present. Most of the left nasal passage defect was filled with packing material made of thin linen dipped in resin. A tubular defect persisted in the right nasal passage which communicates with the superior portion of the cranial cavity. This defect most likely served as the entry point for passing organic materials, possibly a mixture of sawdust, white sand, and resins into the cranial cavity [35] filling more than 90% of the space, fig. (10).

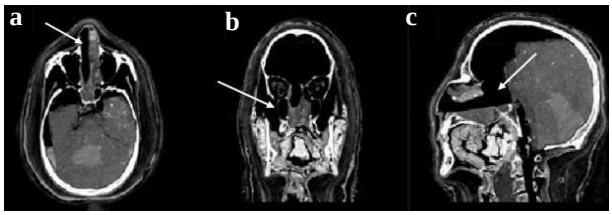


Figure (10) **a.** the tubular defect for removal of the brain thru the nose, **b.** the absence of the ethmoid bone, removed in preparation for extraction of the brain from the cranial cavity, **c.** the tubular defect which communicates with the superior portion of the cranial cavity, also shows packing material (sawdust, white sand, and resins) inside the cranial cavity.

3.5.2. The orbits

During the examination of the eye sockets using CT scan, it was found that the embalmer used the same filling materials as for the cranial cavity, including sawdust, white sand, and thin linen dipped in resin, to fill the orbital cavities. Artificial eyes were not used [36], fig. (11).

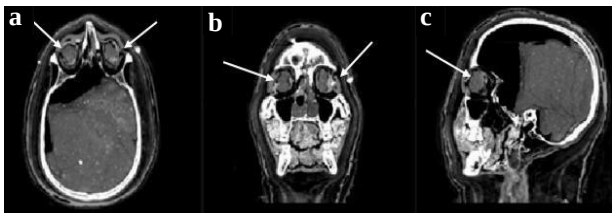


Figure (11) sawdust, white sand, and thin linen dipped in resin fill the orbital cavities.

3.5.3. The teeth

Maxilla: There is a large periapical abscess surrounding the root of the maxillary right 1st molar associated with loosening and migration of the tooth out of the alveolus of the tooth socket. There are periapical abscesses involving the maxillary left 1st and 2nd bicuspids which have also lost their crowns. A majority of the maxillary left 1st molar has been lost with small fragments of retained root tips associated with a periapical abscess remaining. Mandible: The mandibular left 1st central incisor is missing. On the mandible there are carious lesions of the right 1st and 2nd bicuspids, right 1st and 2nd molars and left 1st molar. There is extensive occlusal wear of all of the teeth; stage 8 out of 8 for the maxillary right 1st and 2nd bicuspids, maxillary right 1st molar and maxillary left 1st and 2nd bicuspids. All four of the 3rd molars show stage 5 occlusal wear. all other teeth show stage 6 out of 8 occlusal wears [37,38], fig. (12).

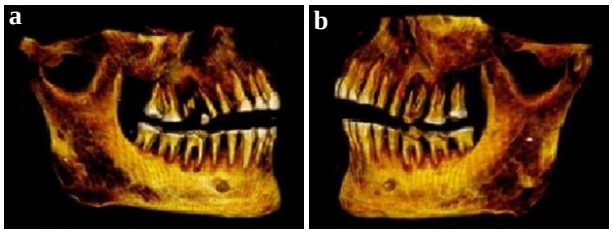
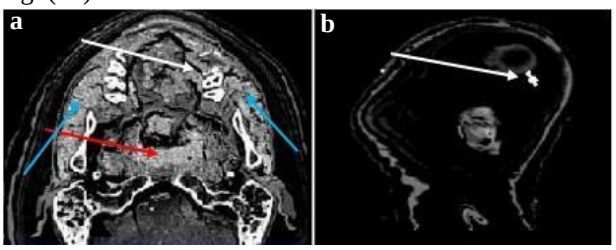


Figure (12) **a.** right teeth **b.** left teeth, reconstruction of the maxillary and mandibular teeth showing extensive occlusal wear, caries, and periodontal abscesses.

3.5.4. The oral cavity

Through interpretation of the CT scan, it was found that the mummy's mouth was slightly open, and the tongue was present inside the oral cavity. The tongue was coated with molten resin for preservation. The embalmer filled the mouth and oral pharynx with organic materials of sawdust, white sand, and thin linen wrappings dipped in resin [39]. Subcutaneous packing materials were placed under the skin of the face from the mylar emineneces to the infraorbital rims and over the body of the mandible to the zygomatic arch effectively restoring the contour of the mummy's face, fig. (13).



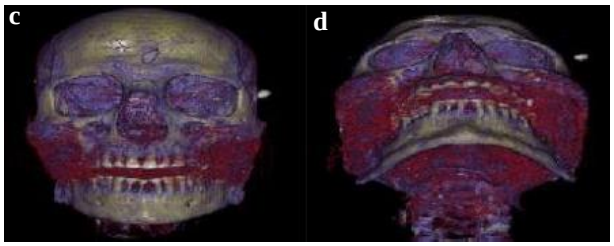


Figure (13) the oral cavity; **a. & b.** the white arrow indicates the presence of the tongue, the red arrow indicates the packing materials in the oral pharynx, the blue arrow indicates the subcutaneous packing materials used under the skin, filling out the cheeks of the mummy's face, **c. & d.** the face; the purple color indicates packing in the orbits, nasal cavity, and cheeks, the red color indicates packing in the mouth and the subcutaneous tissues filling out the contours of the face and cheeks.

3.5.5. The neck

The embalmer recognized the vulnerability of the neck of the mummy, as it supported the skull and the cranial cavity filled with heavy packing materials [40]. In the examined mummy of Tjanefer, the embalmer inserted organic materials into the hypopharynx (throat) and surrounded the neck with linen wrappings soaked in resin [41], fig. (14). Although not in Tjanefer's mummy, occasionally the embalmer would add a wooden stick along the path of the spine to support the head and neck.

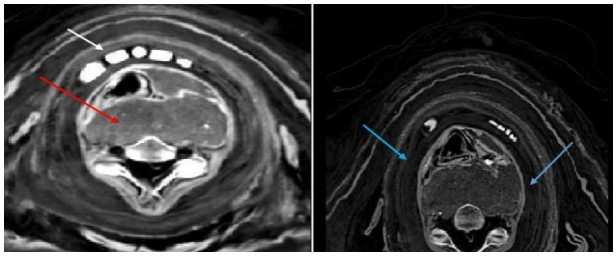


Figure (14) the mummy's neck and first cervical vertebra surrounded by linen strips soaked in resin; the white arrow represents the 5 large amulets of the necklace encircling the neck's exterior, while the red arrow shows the stuffing materials within the hypopharynx and the blue arrows represent the 2 cm thick linen wrappings soaked in resin and white sand surrounding the neck of the mummy.

3.5.6. The thoracic and abdominal cavities

Following extraction of the lungs thru the left abdominal incision described below, the thoracic cavity was filled with sawdust, white sand, and resin along with natron preserved linen packets containing the four sons of Horus [42]. Four additional linen packets were present in the thorax and the abdomen which likely contained the preserved lungs, stomach, liver, and intestines of the mummy. On the left side of the mummy's abdomen, there was an incision measuring (12×4 cm), through which the embalmer extracted the internal organs of both the thoracic and abdominal cavities. The large cavity in the abdominal area was packed with filling materials including sawdust, white sand, and resins. These packing and stuffing materials extended to the pelvis and pubic area, fig. (15). The abdominal incision was subsequently covered with a metal plaque inscribed with the healing Eye of Horus [43].

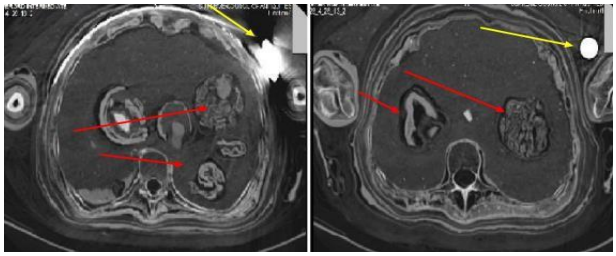


Figure (15) a CT image of the thoracic cavity of Tjanefer's mummy. The yellow arrow indicates the heart scarab location and the wrappings quilling tool. The red circles enclose the visceral packets one of which contains one of the sons of Horus.

3.5.7. The spine

The CT scan revealed that the spine was in good condition. The size of the vertebrae and the spaces between the vertebrae were normal, indicating the absence of injuries or diseases in the spine [44], fig. (16). Packing external to the skin is seen on the anterior surface of the mummy. Subcutaneous packing is present on the upper and lower back.

Figure (16) good condition of the entire spine. (Symbol) shows padding external to the skin on the anterior surface of the mummy. (Symbol) shows subcutaneous packing on the upper and lower back.

3.5.8. The pelvis

The dimorphic features of the pelvis, in addition to the presence of a penis and scrotum, indicate male gender of the mummy. The pelvis contains filling materials of the same description as those found in both the thoracic and abdominal cavities. The penis and scrotum are wrapped in linen soaked with resin and directed backward between the legs creating a protrusion posteriorly. There is packing external to the skin extending over the lower abdomen and pelvis anteriorly and subcutaneous packing posteriorly, fig. (17).

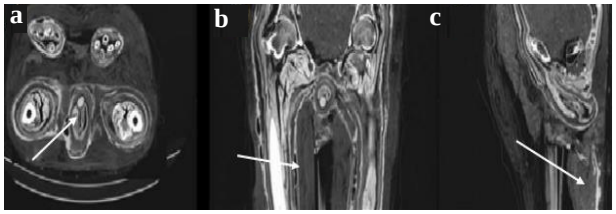


Figure (17) **a.** & **b.** the penis and scrotum wrapped in linen soaked with resin extending from the pelvis and directed backward between the legs protruding posteriorly, **c.** there is padding external to the skin extending over the lower abdomen and pelvis anteriorly and subcutaneous packing posteriorly.

3.5.9. Extremities

The CT scan revealed that the upper and lower extremities, as well as the shoulder girdles of the mummy, were well-preserved [45]. The arms were extended with the hands pronated over the thighs, a common position for the mummies of the priests of Amun during the 3rd Intermediate period. This position was used to hide the phallus as part of the sanctity of the priests' mummies [46]. To restore the shape and volume of the upper and lower extremities, the embalmer used large quantities of linen soaked in resin external to the skin rather than subcutaneous packing [47]. To support the legs before final wrapping, 2 wooden poles were inserted between the legs which extended from the pelvis to the feet. In addition, linen wrappings soaked in resin were added behind the legs for additional support, fig. (18). The feet were intact with linen dipped in resin placed on the insteps of the arches of the feet [48].

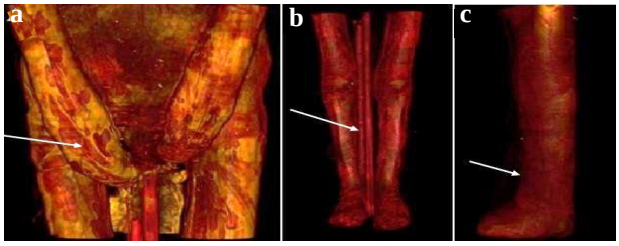


Figure (18) **a.** arms are extended with the hands pronated over the symphysis of the pelvis, **b.** two wooden poles extend from the pelvis to the feet to support the legs prior to final wrapping, **c.** lateral view of the legs after final wrapping.

4. Discussion

Tjanefer's mummy was found to be in an excellent state of preservation. Wrapped composite figurines of the four sons of Horus were found inside the chest cavity. Many distinctive archaeological finds were present on the body of the mummy; three amulets on the skull, a necklace of ten amulets, a heart scarab on the upper chest, a plaque pendant of the snake god Nehebkau behind the heart scarab, and a winged Horus pectoral on the lower chest. On the left side of the thorax, a wrapping quilling tool was present. An inscribed Wedjat eye of Horus was found on a plaque covering the incision for the extraction of the viscera on the left side of the abdomen. A scarab amulet was present on the middle phalanx of the 2nd finger of the left hand. The study verified that the embalmer had successfully extracted the brain through the ethmoid bones of the nasal cavity. Additionally, the embalmer had filled the skull cavity with sawdust and white sand mixed with resin. The internal organs were mummified and placed back in the abdominal and thoracic cavities. Subcutaneous packing was used to replace the fat and muscle loss caused by drying the body with natron salts.

5. Conclusion

The scientific study of the Tjanefer mummy, using CT scan, confirmed several scientific methods used by the ancient

Egyptians in the mummification technique dating back to the 3rd Intermediate period. The archaeological finds discovered in and on the exterior of Tjanefer' mummy provided valuable insights into the mummification process. The CT scan revealed rare artifacts found in mummies, including a wrapping quilling tool that has not been found in any wrapped mummies from other ancient Egyptian eras. The non-destructive examination also revealed that during the 3rd Intermediate period, the embalmer mummified the internal organs outside the body and then returned them into the mummy's thoracic and abdominal cavities. Additionally, subcutaneous packing was used to restore the external form of the mummy's body, which had undergone changes due to the dehydrating effects of the natron salt. The embalmer skillfully mastered this method to rebuild the actual form of the body as in life. The CT scan provided a complete image of the development of mummification, especially during the 3rd Intermediate Period. The examination presented details of the soft tissues, multiple amulets found on the mummy, as well as the details of the linen wrappings and the method used to wrap the bodies. In conclusion, the scientific study of the Tjanefer mummy using CT scan provided valuable insights into the mummification techniques used during the 3rd Intermediate period. The study presented a comprehensive understanding of the procedures used and the artifacts found in the mummy. This research contributes to our knowledge of ancient Egyptian culture and the practices of mummification. The large number of amulets associated with this mummy reflects its wealth and high status in society.

6. Acknowledgments

The author would like to express gratitude to the members of the HORUS Research Team, especially for their contribution to the Computed Tomography Scanning project of Egyptian mummies at the Egyptian Museum. Their expertise and assistance were invaluable in conducting this research.

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