Studying Mummies and Human Remains: Some Current Developments and Issues

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Abstract

This article discusses mummification processes, both natural and intentional, and presents a brief history of ancient Egyptian mummification procedures. The article then provides an overview of existing technologies for analyzing mummies, and the varied uses and applications of examining mummies. It also presents some background and issues related to mummy storage and display in museum environments. Given the ancient procedures used, the limitations of modern analysis techniques, and the existing problems trying to store and display mummies today, the article concludes by summarizing both the current challenges and benefits of the present-day study of mummies, and offering some cautions.

Introduction

THIS PAPER FOCUSES on the task of retrieving information from human remains, with a particular focus on ancient Egyptian mummies. As the human body has not changed much in 5,000 years, information retrieved must be consistent with present human evolution status; traces of diseases still existing today should confer with contemporary specimens. Mummified bodies, regardless of their preservation condition when found, provide important pieces of information in the study of ancient medicine.

There is a designation often associated with mummified remains: the word mummy, that comes from the medieval Latin word *mumia,*[1] borrowed from the Arabic *mūmiyyah*, مومية, which also means *bitumen* – a substance thought in the past to have had medicinal properties.[2]

The Process of Mummification

Various environmental elements, if not controlled, accelerate mummification and transformation of a dead body.[3] These are: the growth of microbial organisms caused by moisture; the presence of food; the human remains themselves; the application of incense, oils and resins; and the effect of plant residues, minerals, and animal fats.

After the body has perished, it loses water, and gases start to form inside the body. Since human bodies are comprised of almost 70% water, the body starts to desiccate (dry) naturally. Environmental conditions may accelerate the reduction of water, release the gases, and start the putrefaction of the tissues. In Egypt, the extremely arid climate favors natural body desiccation.[4] In addition, an adipocere (fatty) substance can be formed and turn the body into a bloated specimen.

Other conditions affect the process after death, and cause the body to lose all its tissue and become skeletonized. These include extreme demineralization with decalcification of bones.

Some bodies are found with one or more of these conditions, depending on whether they were exposed or buried, depending on materials left next to the body, and depending on the amount of light, moisture and air ventilation conditions that were *in situ* over time.[5] Air exposure is crucial in mummification; well-ventilated spaces usually allow bodies to mummify (and desert winds have the same effect). Either hot or cold dry air is a mummifying factor, while moisture enables putrefaction and decomposition.

The presence of insects[6] usually accelerates body skeletonization. There is a specific fauna in the insect group, necrophagi insects, who feed on dead tissue. Several pupae and larvae from different species are often found in mummies, resulting in body decay.

Mummification in Egyptian History

In ancient Egyptian history, mummification started to happen naturally and spontaneously. Natural mummification of bodies[7] was a characteristic of Pre- (5300-3000 BCE) and Early- (3000-2686 BCE) Dynastic Egypt.[8] At first, the bodies were simply placed in the fetal position in shallow oval graves, usually surrounded by personal objects of their daily life.[9] The buried bodies of the deceased became mummified, although the majority of natural mummified bodies found are skeletonized bodies. The mummy called Ginger, housed at the British Museum in London, provides an example of a Pre-Dynastic body, naturally desiccated in the Egyptian sands.[10]

Intentional mummification with evisceration (disembowelment) started from the 4th Dynasty (2613 BCE) onward. The oldest bodies that have been recovered are from that period.

From the Middle Kingdom, 11th to 13th Dynasties (2055-1650 BCE), we have the example of the "Two Brothers" housed at the Manchester Museum. They were first analyzed by Margaret Murray in 1908 and more recently by Rosalie David who wrote about the tomb where they were found.[11]

Most of the bodies belonging to collections and available for study – such as the Royal mummies – are from the:

- New Kingdom (18th to 20th Dynasties, 1550 to 1069 BCE);
- Late Period (26th to 30th Dynasties, 664 to 332 BCE); and
- Greco-Roman Period (Ptolemaic 332-30 BCE and Roman 30 BCE-395 CE).

In Egypt, mummification started fading as a funerary practice in the 7th century CE,[12] probably as a result of the influence of Islam.

Mummification Procedures Used in Ancient Egypt

The techniques developed by ancient Egyptians for mummifying humans were intended to provide the best preservation possible. The materials used, techniques employed, and objects that accompanied mummified bodies are all important and should be considered.

In Dynastic Egypt (3000-332 BCE), coffins appeared to arrest body decay from the artificial process of mummification.[13] In order to prepare bodies for the afterlife, the lungs, intestines, stomach, and liver were removed and preserved in jars, and linen wrappings were tightly fastened to the whole body. The heart was also removed from the chest cavity, but it was treated with unguents, and returned to its anatomical location, usually shielded by a scarab depicting Chapter 30 from the Book of the Dead, for protection in the afterlife.

Up to 12 or more layers of linen bandages can be found on an Egyptian mummy. An optimal mummification procedure would involve changing the linen several times up to 70 days[14] to eliminate all moisture from the body.

Natural factors and ingredients such as dry soil, wind and salt contribute to preserving a dead body from deterioration. The salt used to intentionally dry up bodies in ancient Egypt was natron[15] retrieved from the regions of Wadi Natrun and el-Kab in Egypt, which have natural deposits of this desiccation material.[16]

Liquid resin was then poured into the lying-down body which drained into cavities and solidified there. In Ptolemaic times (332-30 BCE), pitch was also found mixed with the resin in mummies that were analyzed.[17]

Also, it is typical for many bone fragments to be found inside the body vaults and abdomens. Small bones break as the bodies are handled, and they scatter along the large body cavities.

The embalming ritual is described in two Papyri, probably copied from the same ancient source dating from the Greco-Roman period: *Papyrus Bulaq* 3 preserved in Cairo and *Papyrus* 5158 preserved at the Louvre. The Apis embalming ritual, the Vienna Papyrus *Vindobonensis* 3873 used for bull embalming, was also a reference for the priests' practices during mummification of humans.[18]

These ancient Egyptian sources stated that sacred texts were read out loud and rituals chanted while ingredients such as cinnamon, animal fat, and minerals were applied during the mummification process. Embalmers used incense oil, and the resin worked as glue to make the linen bandages stick well. According to ancient Egyptian beliefs, medicine and magic were a bundled concept and the chanting of rituals was necessary during the mummification process.

The role of the priests and their sacred blessings will not be described here in detail[19] except to add that the priests in charge of mummification procedures felt that what was missing in life could not be missing in the afterlife. Therefore, mummified bodies would have artificial body parts attached to them. These artifacts were created to make the bodies whole.

For example, bodies not identified according to their sex could have attached to them fake sexual organs (such as a female thought to be male), false eyes,[20] or prosthetics.[21] A toe may have been added if one were missing.[22] A toe was added to a mummy preserved at the British Museum (British Museum EA 29996). An incisive tooth may have been replaced,[23] or even an entire limb or hand.[24] An example of this is the 'prosthetic' forearm of the Darlington (Durham) mummy (no number); and the fake feet and penis on a mummy in the Manchester Museum (no. 1770).[25] Similarly, a foot prosthetic is displayed in the Cairo Museum (no number). Yet another example of such restoration was found in Mummy 2343 in the Naples Archaeological Museum, where an x-ray test showed two wooden feet to be present. These types of restorations date back to the Ptolemaic Period.[26]

Modern Techniques for Analyzing Mummies

The ingredients that were applied by the ancient Egyptians allowed the bodies to be preserved sufficiently to enable modern-day studies. However, we cannot study mummies in detail without modern technologies. We can now scan human bodies and body parts[27] using non-invasive techniques.

Radiology was one of the biggest inventions to advance the medical observation of both living and deceased humans[28]. With the discovery of x-rays by Roentgen in 1895 and the subsequent development of radiology, a fundamental step was made in medical diagnosis possibilities. Since its invention, radiology has been used to study ancient human remains, including ancient Egyptian bodies.[29] We can learn about historical factors such as what happened at the time of death, the cause of death (*e.g.* blunt force trauma), and weapons used in case of violent death (*e.g.* axes, arrows, swords).[30]

We can also use endoscopy[31] and microscopy (histological analysis) to examine what is found inside a mummified body.

Contemporary computerized software allows scientists and historians to delve into the depths of a 3,000-year-old body either without destroying it or with minimal impact. We can learn how a person lived, suffered, and died – and what kinds of materials were used to preserve the body. Many forensic techniques can be used to examine human fragments. In addition to radiology and the other techniques noted above, these include histology, serology, ancient DNA (aDNA) identification,[32] osteology, as well as paleopathology techniques such as chemistry, isotope and carbon tests. A macroscopic examination should always be performed prior to any such laboratory tests.

Identification of DNA (deoxyribonucleic acid), developed in 1985, helps show family relationships and genetic correlation between individuals.[33] What we can learn from aDNA samples[34] about kinship and paleopathological conditions is limitless. In the aDNA of Egyptian mummies, even the pathogens can be studied,[35] as exemplified by a recent study directed by Zink *et al*.[36]

DNA retrieval methods were improved in 1991 with the application of Polymerase Chain Reaction (PCR) techniques, which allow

DNA to be cloned and produce multiple copies of specific sections of DNA. The long bones of a body tend to provide viable sample material, as they have more bone marrow which can be used for DNA testing. The genetic material -- sometimes presumed lost over time -- may still be viable and valid, and PCR techniques multiply the probability of getting positive results from tests on genetic material.

Some biomedical analysis techniques (*e.g.* computer tomography-CT scans[37] and traditional radiology[38]) have developed very rapidly in recent years. However, they only complement DNA tests.

Uses and Applications for Mummy Research

Through advanced forensic techniques we can learn about: ancient diet;[39] diseases;[40] causes of death (such as plagues infesting crops); climate changes[41] and famines (as shown in bone markers);[42] hemorrhagic fevers caused by bacteria; animals bites and stings; inflammation processes from trauma; genetic disorders, as shown in ancient DNA samples; hair lice; blindness caused by sand,[43] wind or stone quarrying; water worms in the Nile River;[44] and battles.

In general, we can say that many diseases afflicted ancient Egyptians,[45] mostly dental and pulmonary diseases, as their diet contained large amounts of sand. The excessive consumption of meat by high-ranking Egyptian officials may have provoked other diseases such as calcification of the aorta, arteriosclerosis,[46] atheroma,[47] fibrosis in muscle tissues, and aneurysms.

Bone diseases and trauma were also common in human remains from ancient Egypt, although researchers examining the royal mummies[48] concluded that inflammatory bone diseases were rarely seen in ancient Egyptian skeletons. Skeletal conditions included intra-vertebral disc disease and fractures.[49] Bones were subjected to stress from carrying heavy loads,[50] trauma inflicted in battle,[51] horseback riding, boating accidents, and sports. The most common result was osteoarthritis[52] and bone tumours,[53] although the number of occurrences was not high.[54] Nutritional stress and the lack of certain minerals[55] in the diet contributed to these osteological conditions in adolescents and young adults.

More recent tests[56] also show severe infectious diseases. These may have resulted from working in or near the Nile River and its effluents, channels, and ponds; fishing; and interacting with wild animals. Infections like schistosomiasis[57] and leishmaniasis[58] have been identified. Parasites, such as helmintic ova, were found in the PUM II mummy at the Royal

Ontario Museum[59] in Toronto. Other parasites,[60] such as pulmonary silicosis, pneumoconiosis,[61] and malaria[62] have also been found.

Dental diseases[63] were extensive,[64] including dental abrasions, caries, and periodontal disease.[65] Additional conditions that existed include diabetes and heart disease. There were many cases of Harris lines, which are growth-arrest lines.[66]

Various research projects[67] have focused on hair[68] in ancient Egyptian mummies. Researchers have reached astonishing conclusions about hairdressing and the ingredients in cones and unguents used for hair and wigs. Their results show that hair was treated separately from the body, sometimes with different mummification procedures and substances.[69]

As noted, it is common to find objects buried with human remains. Even in a non-funerary context, the excavation of plant remains can be crucial.[70] According to ancient texts, plants were used as medicine in ancient Egypt. This helps explain how ancient diseases may offer answers for contemporary ailments, thus pointing the way to the production of new medicines, perhaps with the help of genetic research.[71]

The study of DNA in ancient bodies is particularly relevant if the intent is to diagram a disease's evolution. An individual's digital genetic imprint is influenced by the genes of his or her relatives.[72] The genes can provide precise information about a family's inherited malignancies and genetic diseases. This is important since royal members in ancient Egypt tended to intermarry among themselves. There are two types of aDNA that can be retrieved from a specimen: mitochondrial DNA is inherited from the mother; nuclear DNA is inherited from both parents and is a more difficult sample to get.[73]

According to Dr. Angelique Corthals,[74] genotype defines phenotype (appearance). The application of DNA testing can help to determine, for instance, whether the strange physiognomy observed in pharaoh Akhenaten and his offspring, possibly including Tutankhamun, derives from a genetic "corridor" (genetically-inherited feature) set up by his ancestors.[75] During the New Kingdom period, the environment did not change substantially enough where this pharaoh and his family lived to disrupt the genetic trace, making it possible to confirm the differentiation of a genetic character in Akhenaten and subsequent passage to his offspring.

Mummy Storage and Museum Display

Mummies can be damaged through: improper display or storage; inadequate humidity level, air movement,[76] and light; and also by fungal spores and insects present in bodies and coffins.

Mummified human remains cannot be stored the same way as other museum artifacts.[77],[78] Humidity in the air and moisture inside the case must be controlled,[79] and dehumidifiers are considered essential, as mummy cases can decay almost as much as their contents, the bodies.

Further, the size of the display cases must be adequate to accommodate the human remains.[80] Being displayed in physically-correct positions – with minimum stress to joints – can ensure that a mummy is displayed without damage. Skulls and other bone fragments must be supported when they are loose from the body. Aluminum splints can be used in broken limbs. Re-bandaging, or re-wrapping, is another option. Paper or other base tissue must be replaced periodically. Foam beds, like the ones used for the Manchester Museum mummies, are also advisable. Mortuary-type trolleys can provide easy movement around museum displays and storage rooms.

Covering human remains has been an issue in some countries. An example of this is a Manchester Museum mummy named Asru who was displayed uncovered until 2008. Following the polemic debate in the United Kingdom, the mummy was covered in May 2008 and later uncovered again.[81]

Challenges in Studying Mummies

Several challenges arise in the study of mummies. One challenge relates to the availability of biomedical techniques. When appropriate techniques do exist, there is also the question as to whether the financial means are available to use those biomedical techniques. There is also the question as to whether the necessary administrative permissions (from museums and other authorities) are in place to allow scientists and historians to do sampling tests.

A factor influencing mummy preservation and museum display is the state in which the mummy is found. Some mummies are very well preserved. In others, contamination may prevent scientists from getting positive results. The majority of disturbances and attacks destroying mummified bodies and skeletons take place post-mortem (after death).

In ancient Egypt, mummies were reburied, misplaced, unidentified, transferred, and housed in different sarcophagi. In antiquity, disruptions occurred mainly due to robbers' activities, political changes, and natural elements that caused the loss of body identification. When moved from Egypt, they were also handled by many people, most not knowing they were handling human remains, or not paying the attention needed.

Most of the findings in archaeological contexts involve bodies that are already disarticulated[82] and groups of bones that are not placed in their original anatomical position. It is common for bones to be missing. Fingers and toes, for instance, are small and easily disarticulated. They get lost on the ground, or in the coffin, and many times they are lost while handling the mummy. When coffins were used that did not fit the size of the mummy,[83] the feet and skulls were often broken.

Once these issues are resolved, analysis of a mummy is not unlike that of a modern day autopsy.

Between the layers of linen wrappings, we may also find amulets,[84] insects, solidified resin, and fungi. The original mummification procedures and ritual chanting allowed time for flies to lay eggs, a factor altering the mummification, and creating disturbing conditions as the body desiccated. Another cause for mold or fungi[85] found in mummies may be re-used linen,[86] as not all ancient Egyptians had the financial means to ensure a "pure" mummification without recycled materials. Some mummies are completely "naked," as illustrated by a female specimen in an Egyptian collection housed at the Faculty of Sciences in Porto, Portugal.[87]

Pollen[88] is also found in mummies, due to the fact that the plants used for oils (used in mummification) carry pollen. This pollen can alter the skin tone sometimes causing the appearance of dark spots. Pollen also appears in coprolites (fossilized feces).

In the absence of contamination, it is possible to sequence DNA.[89] Various types of mummification techniques can impair aDNA retrieval.[90] Some ingredients used during mummification (oils, resins) degrade the tissue to such an extent that aDNA retrieval is almost impossible. As the samples degrade over time, their chemical substances impair any conclusive results. The important issue before taking a sample from a mummy is to try to determinate what materials were used during the mummification process. Alkaloids commonly found in bandages and bodies only reveal some substances, and others are common to various plants and resins used. Therefore, we cannot confirm with total certainty which ones were used in each case.[91]

In terms of DNA extraction, some authors[92] have raised doubts about the conservation of DNA over long periods of time. Studies[93] have been conducted on Egyptian tissue material in order to produce more convincing data. Researchers are attempting to refine information in order to determine when the last DNA molecules vanished. Present results indicate that the preservation limit for archaeological DNA in Egypt is less than 1,000 years. The high temperature levels in the Egyptian environment seem to be the prevailing cause of DNA degradation.[94]

Mummified human remains from ancient Egypt have reached our present time in excellent conditions. There are some extraordinary examples still waiting for complete scanning and DNA tests. These include the "Tutankhamun's fetuses" (1336-1327 BCE) – two girls thought to be sisters (maybe twins, as suggested by Connolly),[95] and who have different body shapes. He believes their differences are symptoms of a rare event in which one twin consumed more nutrients from the mother than the other twin, and was therefore born much bigger and stronger.[96] Premature or severely ill newborn babies rarely survived in antiquity, and often a child died in the mother's womb. It is probable that Tutankhamun's daughters are an example of this, as they were far from full-grown babies who died at five and six month's gestation.

Conclusions

What we can learn from studying human remains is important for both history and science. The study of mummified material allows us to search for diseases that existed in ancient Egypt. The medical, biographical, phenotypal data and accessory information that can be retrieved from mummies on a macroscopic or molecular level is important. Researchers studying mummies must perform detailed analyses of not only the bodies, but also the items surrounding the bodies – including bandages, amulets, prosthetics, false body parts, plants, insects, dyes, and inscriptions. The detailed study of these materials may provide researchers clues about ancient civilization and their scientific and technical knowledge and concerns. Religion and magic were science then. This reminds me of Clarke's third law: "*Any sufficiently advanced technology is indistinguishable from magic*."

Modern non-invasive techniques for analysis provide ample information without destroying the surrounding artifacts. DNA identification is a powerful instrument, although there are disagreements among scientists about the limitations of DNA preservation. However, the most helpful findings and conclusions are drawn from specific tests that require samples which are destroyed in the process. An example: Tests on a tooth's root which requires smashing it, but which can be decisive to prove age at the time of death. For such analyses, special permissions from the museums and institutions housing the mummies are of the essence. Not all museum authorities are sensitive to the urgency of taking samples from human remains.

Ancient human remains come from times when pollution from industry and vehicles, tobacco, genetically-modified foods, chemical drugs, stress, and trauma caused by machines did not exist. This may be relevant from the pharmaceutical point of view. The cores of active substances in our modern medicines are chemical copies of their vegetable counterparts. Those same vegetable substances used with confirmed results by ancient people may point the direction to find better medicines for today.

Bureaucracy and the fear of damaging artifacts should not impede scientific tests that might result in scientific progress today. Contemporary technologies used to diagnose and cure the living should also be made available to address the dead in order to bring history and facts into closer alignment. The texts that survived from ancient Egypt – medical, magical, personal letters, religious or simply funerary – contain information that can be compared with the findings from human remains to confirm treatments and prophylaxis and identify ingredients used.

This information can enlighten our understanding of ancient medicine when brought together in multidisciplinary research projects involving specialists from different fields such as medicine, botany, linguistics, history and imaging. It could change history.

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[1] In Latin, to lie down in aromatic resins, one of the last stages of mummification procedures; Ebeid, (1999):422.
[2] David and Tapp, (1993): 37; Cosmacini et al., (2011): 37.
[3] Vass, (2001): 190-192.
[4] Aufderheide, 2003: 44.
[5] David, (1995): 77.
[6] David, (1995): 78; Parsche, (1992): 877.
[7] David, 1995: 73.
[8] Such as the examples kept at the British Museum, excavated from Gebelein, Egypt; the most famous which is on display being 'Ginger', EA 32751; Micozzi, (1992): 760; Gray, (1967): 34; Aufderheide, (2003): 220; Cesarani et al, (2003): 597.
[9] As depicted by 'Ginger' in the British Museum.
[10] My personal work in collaboration with the team studying the human remains from TT37, under the supervision of Dr. Tiradritti, has enriched my knowledge of how the Egyptian climate can preserve human remains.
[11] Murray, (1910), *The Tomb of Two Brothers*, Manchester, Sherratt & Hughes; David, (2007), *The Two Brothers: Death and the Afterlife in Middle Kingdom Egypt*, Exeter, U.K., Rutherford Press Limited.
[12] Cosmacini et al., (2011): 37.
[13] Veiga, (2009b): 20.
[14] Gray, (1967): 36.
[15] Sodium carbonate, sodium bicarbonate, impurities as salts of iron, calcium and silicon; Gray, (1967) 34-44: 35.
[16] Sandison, (1963): 259-267.
[17] Lucas, (1914): 32.

[18] "(...) The Embalming Ritual is described in two Papyri, probably copied from the same ancient source, dating from the Greco-Roman period, and housed in Cairo: Papyrus Bulaq 3, and at the Louvre, Papyrus 5158. In this last one, the embalming is said to begin only four days after death, the linen bandaging 46 days after, so 42 days are left for the rituals. They used incense oil and the used resin worked as glue so it should be sticky to make the linen bandages stick well. (...) from Veiga, (2009): 22.

[19] Veiga, (2009b).

[20] Van Tiggelen, (2004): 10-14; Gray, (1971): 125-126; Gray, (1967): 36.

[21] Bauduer, (2005): 69-72; Fornaciari et al, (2006): 274-278.

[22] British Museum: EA 29996; Gray, 1966: 138-9, Plates XXXII, XXXIII, XXXIV. The work of my colleague Dr. Jacky Finch, from Manchester has developed around prosthetic medicine in ancient Egypt.

[23] Irish, (2004): 645.

[24] Gray, (1966): 138 and Plate XXXIII.

[25] As Dr. Jacky Finch, who is conducting the research on prosthetics in ancient Egypt was my colleague and is a personal friend. I have followed her research, but there are some scientific publications on that, available at: New Light on Ancient Egyptian Prosthetic Medicine: http://www.nicholasreeves.com/item.aspx?category=Writing&id=75; World's First Prosthetic: Egyptian Mummy's Fake Toe: http://www.livescience.com/4555-world-prosthetic-egyptian-mummy-fake-toe.html; The ancient origins of prosthetic medicine: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2811%2960190-6/fulltext

[26] Fornaciari *et al*., (2006): 274-278.

[27] Strouhal *et al*, (2005): 190-191.

[28] Cosmacini *et al*., (2011): 37-44.

[29] Cosmacini *et al*., (2011): 38.

[30] Waldron, (1992): 847-852; King Seqenenre Tao suffered an injury to his nose resulting in fracture of both nasal bones and destruction of the supra-orbital margin, inflicted by a blunt instrument such as a stick or an axe; Pahor, (1992): 775.

[31] Fornaciari et al, (2005): 255-257; Lambert-Zazulak *et al*, (2003): 223-240.

[32] I owe my specific knowledge in this field to Dr. Angelique Corthals, now in New York, previously at the KNH Center, Manchester, U.K..; Lambert-Zazulak, (2003): 223-240.

[33] When studying the biomedical techniques for Egyptology at Manchester, U.K., I learned about aDNA retrieval and experienced lab work on it.

[34] First published by Paabo, (1985): 644-645.

[35] Zink, (2003): 359.

[36] Published in paper version of National Geographic Deutschland, Zink, A., (2010), Der Dna-Detektiv, Der Fall Tutanchamun, *National Geographic Deutschland*, Hamburg: 30-61.

[37] SCA, (June July 2005): 34-37; Taher, (October November 2007): 10-13; Hawass, (October November 2007): 29-36; Harer, (September October 2007): 8-10; MAES, F. (January February 2005): 8-12; Nelson, (2011): 129.

[38] Too many studies have been conducted so far, in Europe and North America, to mention here. As other references in this article, there are already many cases studied and, if interested, the reader can contact the author for further bibliographic material: veigapau@gmail.com

[39] David *et al*., 2010: 718-719.
[40] Prates *et al*, 2011: 98-103.
[41] Bernhardt *et al*, 2012: 615-618.
[42] Dental hypoplasia and Harris lines on long bones.
[43] Presence of pulmonary silicoanthracosis confirmation in Ventura et al, (2005): 355-356.
[44] Kloos, David, (2002): 14-22.
[45] Veiga, (2009b), chapter 3; Veiga, 2012:63-83.
[46] Bauduer, (2005): 69-72; David, (2005): 175-178.
[47] David, (2005): 175-178.
[48] Smith, (1914): 189-196.
[49] Gray, (1967): 41; Counsell, (October November 2008): 41.
[50] Dr. Jerome Rose has found many cases among the individuals found at the Amarna site; Kemp, (2010): 29.
[51] Bauduer, (2005): 69-72; Galán, (Autumn 2009): 32-35.
[52] David, (2002): 169-173; Gray, (1967): 41.
[53] Strouhal, (2005): 179-183; Fornaciari et al, (2005): 255-257.
[54] Bauduer, (2005): 69-72; Veiga, (2009): 21, 34, 82, 83, 84, 91, 113.
[55] Spigelman, (2005): 91-95.
[56] Cockburn et al., (1980): 59-67.
[57] Horne, (2001): 111-112; David, (2002): 169-173; Bauduer, (2005): 69-72; Rutherford, (2005): 80-83; Kloos et al, (2002): 14-25; Rutherford, (2000): 127-131; David, (2000): 133-135; Kloos et al, (2002): 14-25; Lambert-Zazulak et al (2003): 223-240.
[58] Spigelman, (2005): 91-95.
[59] Cockburn et al (1975): 1155-1160.
[60] Schultz, (1992): 317-320.
[61] David, (2002): 169-173.; Bauduer, (2005): 69-72.
[62] Ibid.
[63] Forshaw, Corthals, (2011): 61.
[64] I owe my knowledge in this specific field to Dr. Roger Forshaw, Honorary Research Associate in Dental Studies at the KNH Center, Manchester, U.K., who helped me with the literature and the examples, as he was a dentist before specializing in medicine in ancient Egypt; Samuel, (1997): 579-580; Filce Leek, (1972): 289-295; Forshaw, (June July 2009): 24-28.
[65] Bauduer, (2005): 69-72; Gray, (1967): 43.
[66] Gray, (1967): 41.
[67] Rabino Massa, (2011): 29-32; McCreesh, (2011): 95-98.
[68] Examples of ancient Egyptian hair exist in several museums, the British Museum being one of those; as proven by BM 54059, BM 6729, BM 22004, BM 6727, BM 6722, BM 6719.
[69] Davies, (2011): 48-51; Personal communications from Dr. McCreesh, October 2007-September 2008, and also on her published work: McCreesh, 2011: 3432-3434.
[70] I am presently working on this subject for my PhD.
[71] The way ancient civilizations dealt with their afflictions and their disturbances of natural order and health might inform the research of today's pharmacological substances, which are chemically altered from plants' natural active substances. Except for some unidentified and extinct plants, the majority of the flora found in ancient

times still exists, and has the potential to be applied to modern medicine, thus permitting a closer encounter between science and history.

[72] David, (2001): 169-173.

[73] Prof. Eugénia Cunha in a seminar of Forensic Anthropology, at the Lisboa Forensic Institute, February 2007.

[74] Dr. Angelique Corthals, CUNY John Jay College of Criminal Justice, Department of Sciences, N.Y., U.S.A.

[75] Zink, (2010): 30-61.

[76] Brancaglion, J. R., et al, (2005): 129-131; De Souza, (2005): 132-135.

[77] Antoine, (2010): 46-51.

[78] David, (1995): 80-86; David, (2001): 243-247.

[79] Pope, (1992): 231-235.

[80] Ibid.

[81] The great mummy cover-up: http://www.guardian.co.uk/artanddesign/artblog/2008/may/23/maevkennedyfriampic; 'Uncover the mummies': http://www.bbc.co.uk/manchester/content/articles/2008/05/22/220508_mummies_egypt_feature.shtml; Museums avoid displaying human remains 'out of respect': http://www.guardian.co.uk/culture/2010/oct/25/museums-human-remains-display

[82] Morimoto, I., (1983): 1.

[83] Janot, (2005): 243-247; Gray, 1966: 138.

[84] Gray, (1967): 41.

[85] Fulcheri et al, (2001): 89-91; Strouhal, (2005): 180; Janot, (2005): 243-247.

[86] Ibid.

[87] Preliminary report published by the author at: *How to Look Ten Years Older: Photos From the Scanning of a Mummy in Porto*, http://heritage-key.com/blogs/veigapaula/how-look-ten-years-older-photos-scanning-mummy-porto

[88] Spigelman, (2005): 93.

[89] Wayne et al, (1999): 457-477.

[90] Paabo, (1989): 1939.

[91] Counsell, (2006): 112-116; Colombini et al, (2000): 19-29.

[92] David, 2001: 113-115.

[93] Paabo, 1985; Paabo, 1989; Nerlich et al, 1997; Zink et al, 2000; Zink et al, 2003; Marota et al, 2002; David, 2008; Donoghue et al, 2010; Aufderheide, 1998; Aufderheide, 2003, and so many others.

[94] Marota et al, (2002): 310-318.

[95] As I have learned this directly from Dr. Connolly, and saw the x-rays at Manchester taken by him and his team, I can point here to several scholarly sources for the subject; Harrison et al, (1979), A Mummified Foetus from the Tomb of Tutankhamun, *Antiquity*, 53, 207: 19-21;A Re-assessment of the Larger Fetus Found in Tutankhamen's Tomb, Une Nouvelle Etude du Plus Grand des Foetus Trouvés dans la Tombe de Toutankhamon, (2009), *Antiquity*, 83, 319: 165-173. More recently a new article may provide additional information; Hawass, Z., Saleem, S. N., (2011), Mummified Daughters of King Tutankhamun: Archeologic and CT Studies, *American Journal of Roentgenology*, 197, 5, W829-W836.

[96] Dr. Connolly explained this theory to me himself, at Manchester's KNH Centre for Biomedical Egyptology in 2008.