The Mediterranean Journal of Otology

REVIEW

Otology and Paleopathology in Ancient Egypt

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This paper was presented at the 5th European Congress of Oto-Rhino-Laryngology Head and Neck Surgery (European Federation of Oto-Rhino-Laryngological Societies [EUFOS]), September 11-16, 2004; Rhodos/Kos, Greece.

Mediterr J Otol 2007; 3: 22-30

Like the classical study of medical papyri, paleopathology uncovers interesting facts concerning ear diseases in ancient Egypt. Three paleopathologic sources are available for the study of ancient otologic disorders: skulls, mummified heads, and middle ear ossicles, all of which will be reviewed in this article. At the beginning of the 20th century, the first studies of skulls with mastoiditis were published. In the second half of the 20th century, the study of mummified heads began to interest ear, nose, and throat specialists. The most well-known mummified heads with a tympanic membrane perforation are housed at the Pennsylvania University Museum in Philadelphia, US (the mummy of PUM II) and the Royal Ontario Museum in Toronto, Canada (the mummy of ROM I). Less well-known mummies can be found in the Mook Collection of the Institute of Anthropology in Munich, Germany. Recently, the study of auditory ossicles excavated in 1988 from a necropolis near Minshat Abu Omar in the eastern Nile delta by the second author (W. P.) added new information to the science of otologic paleopathology: One hundred and sixty-one ossicles from the Ptolemaic period showed signs of bone erosion that was probably caused by middle ear infection. The reading of medical papyri promotes the study of the symptoms of ear diseases without the benefit of the clinical and pathologic images of those diseases, both of which are provided by paleopathologic analysis. Experts have concluded that middle ear infections and their sequelae were indeed present in ancient Egypt.

Paleopathology is the study of diseases of the past, and in particular of those times for which no literary sources exist. In 1910, Ruffer defined paleopathology as "The science of the diseases which can be demonstrated in human and animal remains of ancient times."[1]. Ruffer was concerned only with ancient Egypt, and for that reason Moodie[2] and Janssens[3] expanded the definition of paleopathology to include "not only the diseases on the mummified animal and human remains of Egypt, but those of very ancient animals."

Paleopathology is an integral part of the history of medicine. It provides primary evidence of the state of health of our ancestors and supplies biological and cultural data. The study of paleopathology is multidisciplinary and is based on primary and secondary sources of evidence. Primary evidence is derived from the skeletons or mummified remains that provide the most informative evidence of disease. Secondary (and more subjective) forms of evidence include contemporary, documentary, and iconographic data. One of the most vexing problems for a paleopathologist is the question of whether a given tissue change is an antemortem pathologic lesion or a postmortem artifact (a pseudopathologic condition). The study of paleopathology begins with an understanding of the ways in which a disease affects the body in the modern clinical sense[4]. There are many limitations to that type of study. However, a striking feature in the study of the history of disease is the constant nature and distribution of diseases with the passage of time.

Paleopathology has been studied since the 18th century, but it was not until the beginning of the 20th century that this new science was expanded systematically, notably in applying the methods of radiology, histology, serology, and deoxyribonucleic acid analysis. In the second part of the 20th century, paleopathology became an interdisciplinary science that included features of epidemiology and demography, as well as innovations in clinical techniques and laboratory analysis, all of which enabled a more accurate diagnosis of paleopathologic conditions[5].

The aim of our study was 2-fold: first, to review published data from the otologic examination of Egyptian skulls, mummy heads, and middle ear ossicles of the pharaonic era (including a review of mummy heads from the Mook collection in the Institute of Anthropology in Munich, Germany), and then to present the results of an excavation of middle ear ossicles from a necropolis near Minshat Abu Omar performed in 1988.

The identification of ear disease in human remains is difficult. In particular, the reaction of bone to infection may vary from generation to generation, and therefore the type of disease cannot be confidently identified on the basis of changes in bone. It is also difficult to imagine the changes that must have occurred in the mastoid region during recovery and to know whether the mastoid cells were simply absorbed to form a cavity or if their shape was to a degree restored as the patient recovered. Another difficulty involves the extrapolation of our knowledge of ear diseases today to the progression and characteristics of ancient ear diseases[6]. The fibrous and bony elements of the ear and temporal bone can be well preserved by and easily identified after mummification. Softer tissues survive less well, in part because of the crude methods of preservation and the inaccessibility of the ear structures to the embalmers' craft. In addition, it is not possible to use invasive techniques, such as those required for histologic analysis, to examine mummified remains. This limits the investigation to direct observation and the results of radiologic and endoscopic studies.

SKULLS

Skulls were the first human remains to be extensively studied from a paleopathologic perspective. Early studies of skulls revealed a wide variety of pathologic anomalies, particularly traumatic fractures and osteitis. In addition to several cases of exostosis of the external auditory canal[7,8], a few skulls with affected ears were cataloged; in particular, a predynastic skull, an early dynastic skull, a Tarkan skull, and a New Kingdom skull.

The oldest known skull from Egypt is a predynastic skull (before 3000 BC) that belongs to the Royal College of Surgeons and was transferred to the British Museum (Figure 1). Unfortunately, owing to bomb damage in World War II, part of that specimen (including part of the diseased area) is no longer available. In that skull, there is little doubt that the antemortem destruction of the right mastoid region was caused by acute mastoiditis with widespread erosion. The erosion had reached the lateral sinus and may have caused a sinus thrombosis, but there is no evidence of intracranial extension apart from that feature, and the cause of death is uncertain. There is no sign of healing, and this individual probably died from the extensive inflammation of the ear region[9].

Figure 1: A New Kingdom skull with mastoid destruction (from Smith E, Dawson W. Egyptian mummies. New York: Dial Press, 1924).

A predynastic or early dynastic skull (before 2300 BC) that was found in a cemetery, situated in a khor behind the village of Gerf Husein on the Nile side shows evidence of mastoid disease that had probably developed in the middle ear, destroyed the anterior wall of the left external auditory meatus and tympanic plate, and involved the temporomandibular articulation. The condyle of the mandible was destroyed by the pathologic process, which had spread backward into the mastoid antrum and opened into the lateral sinus. The antrum communicates with the outside via several apertures at the site of the suprameatal triangle. Although the description suggests mastoid disease in most respects, it is interesting to note the apparent involvement of the temporomandibular joint[10].

The early dynastic Egyptian skull from Tarkhan, which is displayed in Duckworth Laboratory in Cambridge, GB has a well-defined breach in the meatal wall that might be the sinus of a mastoid abscess. Although the sinus usually runs behind the spine of Henle and not in front, as in this case, the pathologic characteristics suggest early mastoiditis. Of special interest is the fact that a fairly well-healed trephine hole is situated at some distance of the mastoid area on the parietal bone of the same side[6]. Although this association could be accidental, it seems equally probable that trephination was used as a curative procedure[11].

In an adult female skull (1550 to 1080 BC) of the New Kingdom period, found in a Nubian cemetery, the surface of the temporal bone has an outward perforation that led to periostitis and necrosis of the bone surface around the site of the perforation. This suggests a septic disease of the antrum. Behind the right external auditory meatus there is a definite patch of the temporal bone that demonstrates inflammation and necrosis, and above the diseased area, an oval sinus communicates with the antrum of the mastoid. The sinus is situated in the suprameatal triangle, and at its bottom is necrosed bone showing the opening of numerous mastoid cells. The infection of the bone below the sinus was for the most part superficial and was the result of periostitis that spread downward from the discharging mouth of the sinus[7].

In the cemetery of Minshat Abu Omar, we found 1 clearly eburnated mastoid in each of 68 excavated skulls and in a mummy head (Figure 2). In his radiologic studies, Moodie demonstrated 1 case of eburnated mastoid in a female predynastic mummy head (Figure 3)[12]. Hrdlicka examined 454 Egyptian skulls (the oldest of which dates from 2000 BC) and found exostoses in 1.3% of the external auditory canals [13].

The study of ancient Egyptian skulls shows that mastoiditis was a known illness in ancient Egypt and that exostoses were also present. The destruction of the mastoid wall and mastoid cells suggests that most cases of mastoiditis were probably acute, but cases of

eburnated mastoid also occurred and were doubtless associated with more chronic infections of the ear.

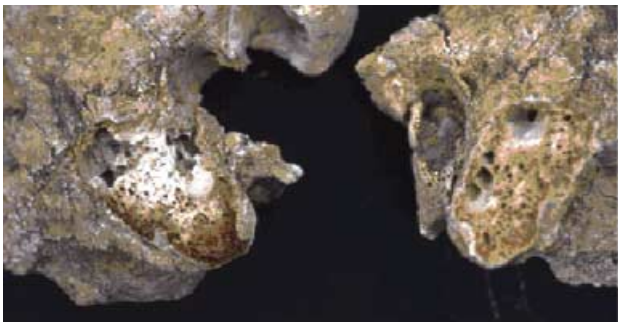

Figure 2: An eburnated mastoid found in the cemetery of Minshat Abu Omar in the eastern Nile delta.

Figure 3: Radiograph of an eburnated mastoid (from Moodie R. Roentgenologic studies of Egyptian and Peruvian mummies. Chicago: Laufer, 1931).

MUMMIES

No relics of antiquity have been more romanticized or made the subject of more incredible misinformation than have ancient Egyptian mummies. A mummy is the body of a human or animal that has been preserved by any means, either deliberate or accidental. Ancient Egyptian mummies, which are some of the oldest examples of these preserved bodies, are the result of centuries of experimentation by embalmers. The purpose of mummification in ancient Egypt was 2-fold[14]. The body of the deceased had to be preserved to render it incorruptible, and his or her physical appearance had to be as similar as possible to its form in life. In the predynastic era, no embalming was performed; a corpse was simply placed in a hole in the sand, where it desiccated in the hot, dry sand and was thereby naturally preserved. At the beginning of the dynastic or pharaonic age (3000 BC), the innovation of entombment resulted in the removal of the body from the surface area of the warm sand, and it became necessary to invent a technology that would preserve physical remains. The art of mummification, which was originally reserved only for pharaohs, was developed to answer that need. Around 1050 BC, the art of mummification reached its height, but that practice declined slowly until the introduction of Christianity in the first century AD. Unfortunately, no written details recount the process of mummification except for the writings of Herodotus, who describes 3 levels of mummification[15]. Of all the hundreds of thousands of bodies that were prepared by the ancients, only a small percentage exists today. Museums all over the world are undertaking the analysis of their Egyptian human remains and are comparing their results, especially those concerning the diseases from which ancient Egyptians suffered.

Many mummy heads have been studied in detail, but few analyses have been focused on the organs of hearing, with the exception of studies of the mummies of PUM II and ROM I. Now in the Pennsylvania University Museum, PUM II was a man who died around 1700 BC at 35 to 40 years of age. Examination of his ears revealed intact auricles, and otoscopic evaluation disclosed an intact left tympanic membrane and a small perforation in the right tympanic membrane. The perforation, which is located in the posteroinferior part of the tympanic membrane, is scarred with smooth and concise margins. A histologic examination of the margins of the perforation revealed evidence of a histologic repair with no abrupt cuts, which indicates that this apparent repair is not an artifact. In the middle

ear, the ossicles are intact and in a normal position. The mastoid air-cell system is normal in appearance. The inner ear is not well preserved. These observations suggest that PUM II suffered from a middle ear infection with necrosis of part of the tympanic membrane, which remained stable after the infection had healed [16].

The Royal Ontario Museum houses the mummified head of ROM I, who probably died around 1760 BC. Otoscopic examination revealed a left perforated tympanic membrane with abnormal position of the ossicles. Although the 3 ossicles are grossly dislodged, they are normal in form and size and show no sign of erosion or destruction, which suggests that this finding is a postmortem artifact. The squamous epithelium of the eardrum is fragmentary, and the mastoid air-cell system is poorly aerated. Several mastoid air cells are filled with fibrous tissue, and in the posterior portion, the mastoid process is relatively sclerotic. The inner ear is normal in appearance [17,18].

Other less well-known mummy heads (those of ROM II, Se-Ankl, and Iret-Irew) have also been studied. In the Royal Ontario Museum is the mummified head of ROM II, who probably died between 2043 and 1674 BC. In that specimen, the air-cell system of the mastoid is extensively well pneumatized. The tympanic membrane and the ossicles are not visible in either ear on otoscopic examination. An overhanging fallopian canal can be seen on the left side [19].

The Department of Egyptology of Memphis University houses the mummified head of Se-Ankl, which dates between 330 and 304 BC. In that mummy, the external auditory canals are normal in appearance. The mastoid system is well pneumatized, the tympanic space is of normal dimensions, and the ossicles are in the correct anatomic position without alteration. Both the cochlea and the labyrinth have normal morphologic features. A dominant right jugular bulb that deeply imprints the undersurface of the petrous apex can be seen [20].

Also in the Department of Egyptology of Memphis University is the mummified head of Iret-Irew. In that head, the auricles have been wrapped forward by linen bandaging and have assumed a somewhat unlifelike position. The external auditory canals are of normal size and shape. The tympanic space and the ossicles are of normal size and are in the correct anatomic position. In the left attic is a spherical mass adjacent to the body of the ossicles. No evidence of bone erosion can be seen. This mass is of the same radiodensity as the embalming resin that is layered in other body spaces; however, because of its nonlayered shape and location in an other-than-dependent site, a diagnosis of chronic inflammation, cholesteatoma, or tumor cannot be ruled out. The inner ear is normal in appearance. A dominant right jugular bulb deeply imprints the undersurface of the petrous apex[20].

Our study included 57 mummy heads from the Mook Collection of the Institute of Anthropology and Human Genetics in Munich, Germany. These heads were mummified in the area of Thebes and Abydos between 1500 and 1000 BC. They were examined externally with special attention to the ear. When otoscopic examination was possible (Figure 4), it was performed by the senior author (W.P.) with a flexible endoscope, and all clearly visible tympanic membranes were documented. It is important to note that many normal external auditory canals were plugged with wax or linen during embalming, which often destroyed the tympanic membrane and the middle ear (Figure 5). In addition, the first attempts to observe the external hearing canal with a flexible endoscope were difficult because of the absorption of light by the black bitumen[21,22]. Nevertheless, 9 external hearing canals on 6 mummy heads were examined. All demonstrated tympanic membrane perforations of different sizes and locations. Six perforations are total, from which four present the ossicles in place (Figure 6). The same mummy head was found to have 2 tympanic membranes with multiple perforations and slight attical retraction (Figure 7). One of those 2 perforated membranes has an inferior perforation that was poorly delimited because of the bitumen. In 1 case of total perforation, the middle ear is filled with insects (Figure 8).

Figure 4: A right ear with a patent external auditory canal (from the Mock collection, ÄAnat I, Institute of Anthropology in Munich).

Figure 5: A destroyed tympanic membrane and ossicles (from the Mock collection, Institute of Anthropology in Munich).

Figure 6: A left middle ear with 3 ossicles; note the bitumen (from the Mock collection, 1018, Institute of Anthropology in Munich).

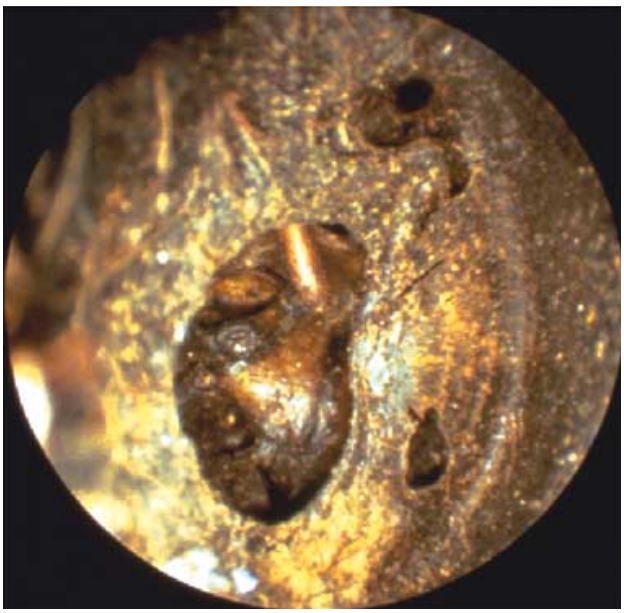

Figure 7: Multiple right tympanic membrane perforation (from the Mock collection, 567(1) Thebes, Institute of Anthropology in Munich).

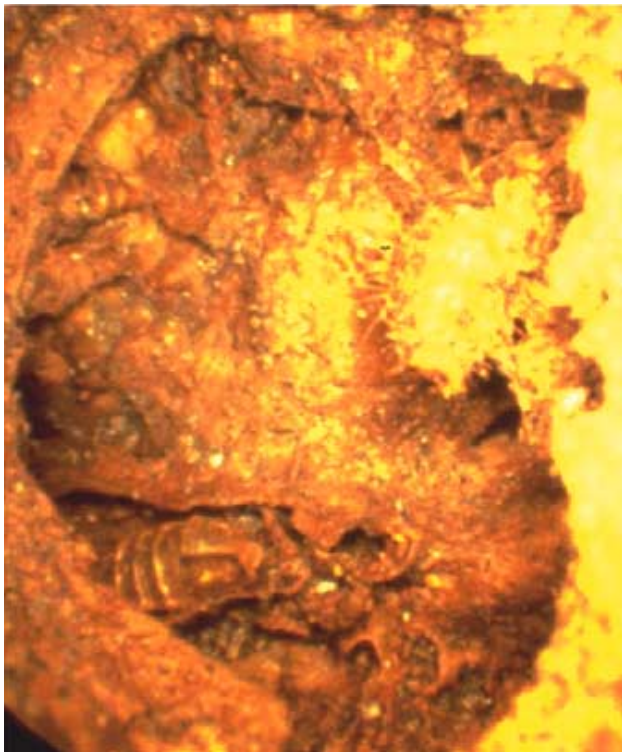

Figure 8: Total destruction of the middle ear; note the insects (from the Mock collection, I1026, Institute of Anthropology in Munich).

The interpretation of these findings is difficult. The cases of total perforation are certainly postmortem artifacts of embalming. No remnant of a tympanic membrane is recognizable. The presence of bitumen in the middle ear in most of these cases confirms this hypothesis. The bilateral multiple perforations on the same mummy head are probably related to antemortem processes. The results of precise examination show that the borders of those perforations are regular and might have been caused by scarring.

Our principal interest in studying mummy heads is the possibility of examining the tympanic membrane and the middle ear contents in detail when a perforation is present. Without histologic examination, it is difficult to confirm that a perforation was present before death. Nevertheless, the regularity of the borders is a good indication of an antemortem pathologic condition, as demonstrated by Benitez[16]. The presence of a tympanic membrane perforation with healed borders signals the existence of chronic otitis media in ancient Egypt.

MIDDLE EAR OSSICLES

Paleopathologists have not focused much attention on the study of middle ear ossicles in ancient Egyptian skulls and mummies, primarily because many ear ossicles are lost during excavation and because it is difficult to examine the ossicles without destroying the skull (Figure 9). The ossicles are enclosed and protected

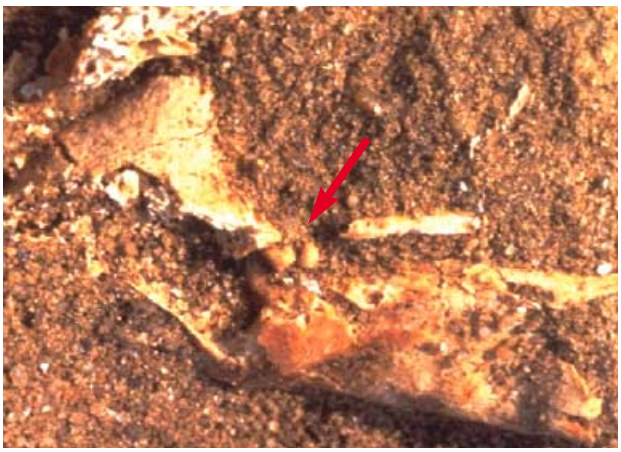

Figure 9: Middle ear ossicles (->) excavated from Minshat Abu Omar.

by the temporal bone, and because of their particularly solid bony structure, they are fairly resistant to postmortem decomposition and have usually been very well preserved by embalming or natural mummification in the hot, dry sand. We present a series of 161 ossicles from 68 skulls and mummy heads (113 temporal bones) that date from 700 BC to 400 AD (the late Egyptian-Greek-Roman-Coptic period) and that were excavated from a cemetery near Minshat Abu Omar in the eastern Nile delta in 1988. These ossicles had been desiccated and naturally preserved by the heat and dryness of the sand in which they were buried. The first evaluation of these specimens was presented in 1992 [23]. Seventy-five incudes, 56 mallei, and 30 stapes were found and examined microscopically. The ossicles were detected in their normal position in only a few temporal bones. In most skulls, fine sand had scattered the ossicles into the external hearing canal, within the bony wall of the Eustachian tube, in the area of the antrum, and even in the mastoid cells. In more than 87 ossicles (50%), local

alterations were visible as pitting and erosive changes (Figure 10). The fine observation under the binocular operating microscope enables the differentiation of such alterations from artifacts and postmortem modifications. The question behind these alterations is their origin. It can been suggested that a middle ear infection with partial bony destruction as usually found in a person with necrotizing acute otitis media or chronic otitis media could explain these findings, which we often see in our daily surgery of middle ear diseases. Nevertheless, these results suggest that middle ear infections existed in ancient Egypt.

Figure 10: An eroded incus from Minshat Abu Omar.

Although many Egyptian skulls, mummy heads, and ossicles have been examined, evidence of temporal bone or middle ear disease has been noted in very few cases. Mastoiditis and middle ear infections would be recognized. This indicates that the 2 main diseases of the ear, acute and chronic otitis media, existed in the most remote antiquity. However, a lack of sufficient data prevents the derivation of conclusions concerning the incidence and severity of those diseases. Although many disorders can be diagnosed via paleopathologic studies, it is very difficult to identify nosologic entities on the basis of ancient texts. This is because in ancient times (and in fact until quite recently) in the history of medicine, man had no clear idea of the existence of separate nosologic entities; that is, of diseases that affect specific organs and produce certain symptoms. For early mankind, there were only symptoms, and because of an ignorance of pathology, those symptoms were interpreted as the disease itself.

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