ANTHROPOLOGIE • LXII/3 • pp. 179–188 • 2024

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THREE CASES OF *CONCHA BULLOSA* IN ANCIENT EGYPT (LUXOR, CA. OVER 2000 YEARS AGO)

ABSTRACT: The purpose of this study is to underline the importance of Concha Bullosa (CB)*, a pathological condition frequently missed in the analysis of human remains in archeological studies. We studied three cases from the Ancient Egyptian necropolis of Dra Abu-el Naga, located on Luxor's (Ancient Thebes) West Bank of the Nile. The sample object of this study belongs to different chronologies, but all were over 2,000 years old. The analysis included both macroscopic and radiological examinations of three skulls, all of adult males, showing different degrees of involvement of the middle turbinate. One presented with extensive bilateral CB without deviation of the nasal septum. The others showed unilaterally without affecting and deviating the nasal septum. The maxillary sinuses were not affected. The embalming technique varied throughout Ancient Egyptian history, with brain extraction first practiced among elites and then spreading across all social classes. This removal of the brain, if carried out through the nose, involved the destruction of the nasal bones. That may be the reason for the paucity of the described cases in the high number of individuals examined, added to the lack of familiarity of the investigators with this entity. These three new cases add to the body of existing evidence on CB and stresses the importance of not missing its identification during paleopathological studies.*

KEY WORDS: Ancient Egypt – Concha Bullosa – Middle Turbinate – Pneumatization – Paleopathology

INTRODUCTION

The turbinates are shell-shaped bony structures on either side of the nasal septum, which separates the left and right sides of the nose (Feneis 1994). They are covered by a mucous membrane and their function is to expand its surface to exchange heat and humidity with the breathing air, cushioning the air's entry impact into the lungs (Riera *et al.* 2002). Particularly, the inferior turbinate is a separate bony structure, while the middle and superior turbinates are part of the ethmoid bone (Feneis 1994), forming the lateral wall of the nasal

Received 28 March 2023; Accepted 13 May 2024. Available online 30 October 2024.

DOI: https://doi.org.10.26720/anthro.24.08.07.1

cavity. The *Middle Turbinate* (MT) limits the opening of the maxillary sinus, the largest of the paranasal sinuses, and is composed of bulbous and lamellar portions (Gawlikowska-Sroka *et al.* 2016). *Concha Bullosa* (CB) is generally defined by the partial or total pneumatization of the MT that leads to a significant increase in its size (Uygur *et al.* 2003, Gawlikowska-Sroka *et al.* 2016, Galassi *et al.* 2024). This pneumatization can also be observed in the superior or the inferior turbinate, although less frequently (Bolger *et al.* 1991, Doğru *et al.* 1999, Braun, Stammberger 2003, Galassi *et al.* 2024). Pneumatization of the three turbinates is extremely rare (González *et al.* 2005, Kalaiarasi *et al.* 2018, Rubio *et al.* 2019).

Some authors considered CB as a normal variant of the paranasal sinus region (Kalaiarasi *et al.* 2018), frequently asymptomatic (Joe *et al.* 2000). However, pneumatization of the MT can lead to various clinical pathological pictures.

The etiology of MT pneumatization has not been fully clarified. Some authors suggest a strong genetic component (Chaiyasate *et al.* 2007), but the incidence of CB is highly variable throughout the world. Current studies place it between 9% (Lothrop 1903) in the American population, and 56% (Unlü *et al.* 1994) in the Turkish population, although with a large difference in prevalence depending on the regions (Bolger *et al.* 1991, Uygur *et al.* 2003, Lee *et al.* 2013, Al-Sebeih, Bu-Abbas 2014).

Paleopathological references are very scarce (Mays *et al.* 2011), especially in BCE chronologies. One case from Tepe Hissar (Iran) between 3500–3000 BCE (Krogman 1940). One case from Sheikh-Abd-el-Gurna necropolis, in Ancient Egypt (Hagedorn *et al.* 2002). Three cases from Oxyrhynchus (a necropolis from Roman times in Egypt; Isidro, Malgosa 2003). Four cases in the Bronze Age, two in Spain (Cuesta 2008, Rubio *et al.* 2019) one in Croatia (Hincak *et al.* 2013) and one in the Baltic Sea (Derums 1978). The rest of cases mainly grouping in the Middle and Modern Ages (Cuesta 2008, Kwiatkowska *et al.* 2011, Mays *et al.* 2014, Rubio *et al.* 2019, Galassi *et al.* 2024).

The study of this pathology has several points of interest. On the one hand, adding three cases of BCE to the scarce paleopathological literature on CB and, particularly from the same area of the Luxor necropolis (the Ancient Egyptian city of Thebes), although with a varied chronology, from the Third Intermediate Period

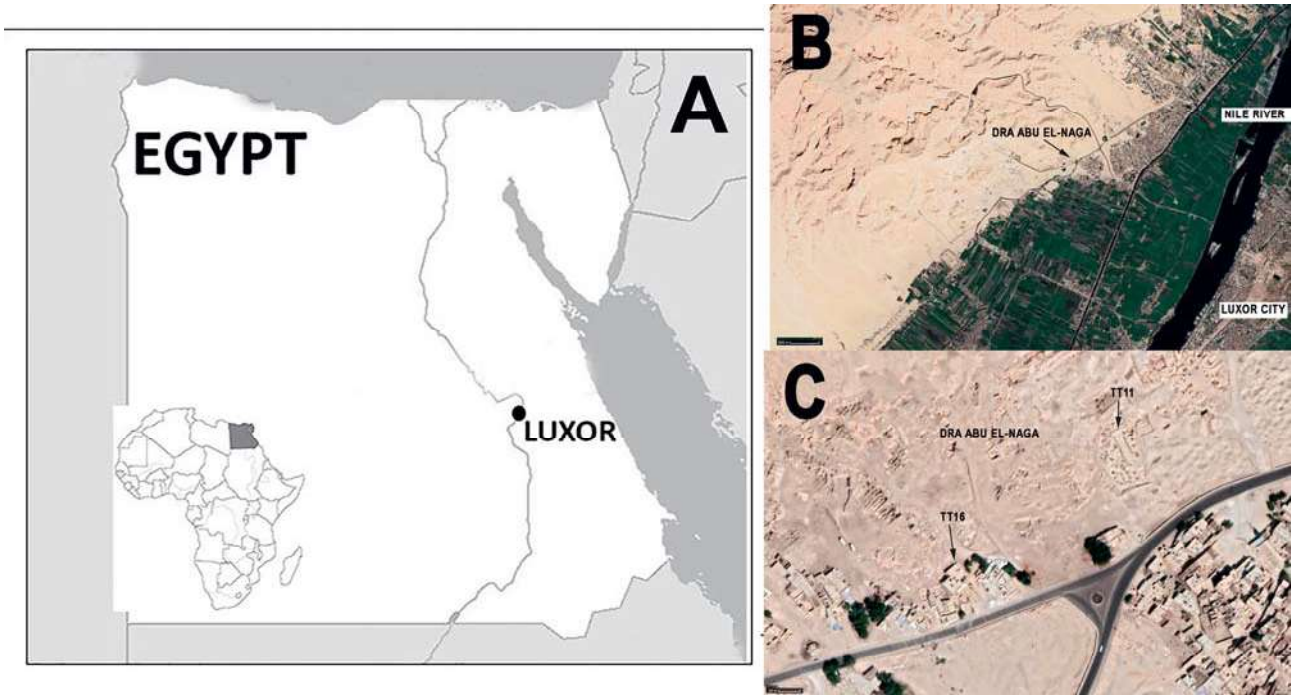

FIGURE 1: A, Location of Luxor (Ancient Thebes), Egypt. B, Location of Dra Abu El-Naga. C, Position of TT16 and TT12.

to the Roman Period. In this way, this article hopes to contribute to a better understanding of this pathology, well known in current clinical practice but which seems to be underdiagnosed in paleopathological studies (Galassi *et al.* 2024). The fact that it is considered an anatomical variety according to some authors may influence its underdiagnosis, but we think that the difficulty of correct preservation of this anatomical area is the greatest limitation.

MATERIAL AND METHODS

These three analyzed cases are remains from Ancient Egypt, exhumed in the region of Dra-Abu-el-Naga (Luxor, Egypt, ancient Thebes; *Figure 1*). Dra-Abu-el-Naga is a hill on the west bank of the Nile River in ancient Thebes. The climate is desert, with almost no rainfall and high temperatures most of the year. Two were found in the Panhesi's tomb (TT16; 25.735082 N; 32.621524 E), and a third in the Djehuty Project excavation area (TT11; 25.736411 N; 32.623360 E). Panhesi's tomb (TT16), a Ramesside tomb, has been excavated since 2010, in a project funded by the University of Memphis (USA) (Herrerín *et al.,* 2014). The two cases found in the Panhesi's tomb have a difficult chronology to pin down. The tomb was reused over a very long period of time, so they could belong from the Third Intermediate (1070–650 BCE) to the Roman period (30 BCE–300 CE) (Herrerín *et al.* 2014). The third skull was exhumed during the Djehuty Project (TT11, Luxor, Egypt). The Spanish mission working at Dra Abu el-Naga North conducted its first archaeological campaign in January 2002, focusing on the rock-cut tomb-chapels of Djehuty (TT 11) and Hery (TT 12), two hypogea dated to the beginning of the 18th dynasty (Galán 2019).

An macroscopic and radiological analysis of each of the skulls was carried out. A portable X-rays 9020 HF Clarox Equino machine was used, with the following parameters: 1.35 kW, 90 kV and 15 mA. Sex was determined according to cranial morphology (Ferembach 1979, Buikstra, Ubelaker 1994) and age at death was estimated on the degree of synostosis of the cranial sutures (Meindl, Lovejoy 1985) and dental wear (Brothwell 1963, Lovejoy 1985, Al-Sebeih, Bu-Abbas 2014). Regarding CB, the Bolger et al. classification (Bolger *et al.* 1991) was adopted, which divides the types of involvement of the turbinates into three types: *lamellar* (pneumatization of the vertical lamella of the MT); *bulbous* (pneumatization of the inferior or bulbous segment of the MT) and *extensive* (pneumatization of both portions, superior or lamellar and inferior or bulbous of the MT). To assess the deviation of the nasal septum, the angle, defined as the one between the septum axis and the mid-sagittal line (Uzun *et al.* 2014) was calculated, differentiating three groups: Group A (<3°), Group B (3–10°) and Group C (>10°). Deviation of the nasal septum may be due, among other causes, to the presence of unilateral BC.

RESULTS

TT16-11-2.2-FEB07-BOX13-IND01:

It is an isolated not excerebrated skull without his jaw. The skull has the cribriform plate of the ethmoid bone intact, one of the favorite places chosen by embalmers for the extraction of the brain. The presence of the *lamina cribrosa* and the occipital bone without fractures indicates that the brain was not removed.

Sex and age were estimated as male adult (35–49 years), based on the closure of the cranial sutures and the wear of the only preserved tooth, a right upper first molar. There was a marked increase of the size of both middle turbinates (*Figure 2A, B, C*), with a significant occlusion of the nasal meatus, easily observable from the anterior view (*Figure 2A, B*). The nasal septum (Group A; <3°) had not undergone a significant displacement (*Figure 2B, C*). The maximum median lateral width of the right MT was 14.1 mm and 13.8mm on the left side. The macroscopic and radiological analysis revealed no signs of infections in the nasal cavity or paranasal sinuses. The superposition of the skull structures does not allow a correct visualization of the *concha bullosa* in conventional radiology images. However, these images were used to demonstrate that the formations are empty and that the walls of the sinus are not affected, since the floor of the maxillary sinus cannot be analyzed by radiography.

The MT walls had a smooth appearance, with no subperiosteal hyperostosis. It was considered a type of *extensive* CB, as both parts, lamellar and bulbous, of the MT were compromised. The maxillary sinuses were not affected.

TT16-10.3-BOX01-IND01

Corresponds to a complete splanchnocranium, with a preserved calotte part of the frontal bone and fragments of temporal and parietal bones. The skull showed a black spot in the center, brown on the edges, indicating that it was partially burned by postmortem processes unrelated

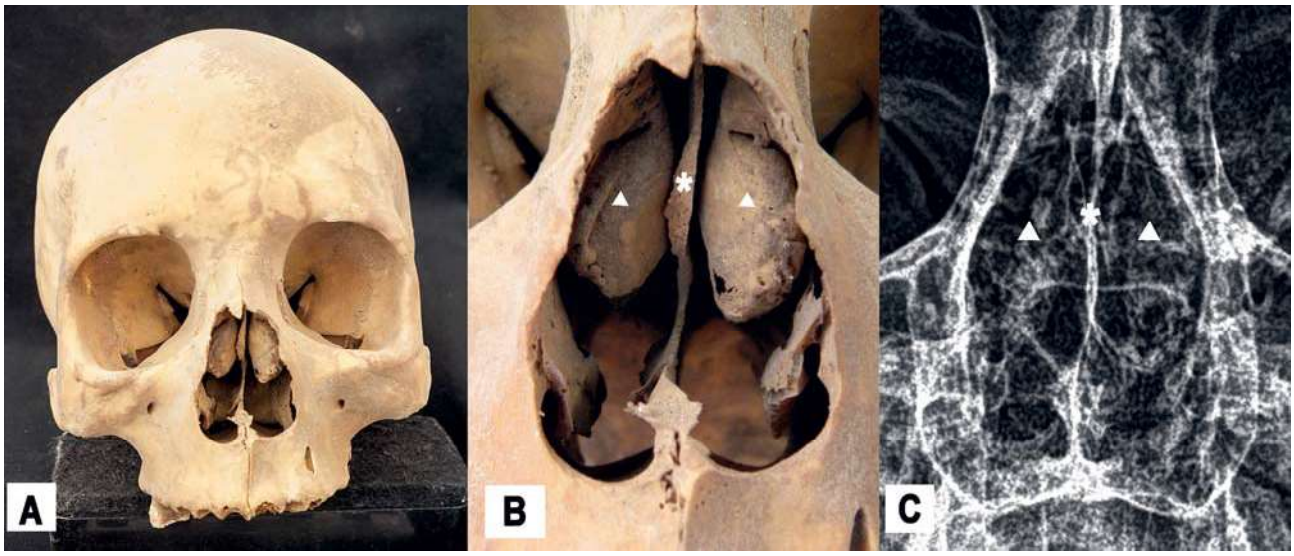

FIGURE 2: [TT16-11-2.2-FEB07-BOX13-IND01]. A, Skull – frontal view. B, Detail of bilateral and extensive *Concha Bullosa*. C, antero-posterior X-ray image of the nasal area. White triangle shows the middle turbinates, asterisk the nasal septum.

to the time of burial (*Figure 3A*). There were no signs of excerebration, showing intact the ethmoid cribriform plate. It was a male young adult. The skull showed an increase in volume of the right MT (*Figure 3B, C*). The nasal septum was slightly deviated to the left (Group B*; 3–10°), with asymmetry in the nasal cavity. It was considered a *bulbous* type CB. There was no presence of new bone formations within the maxillary sinus.

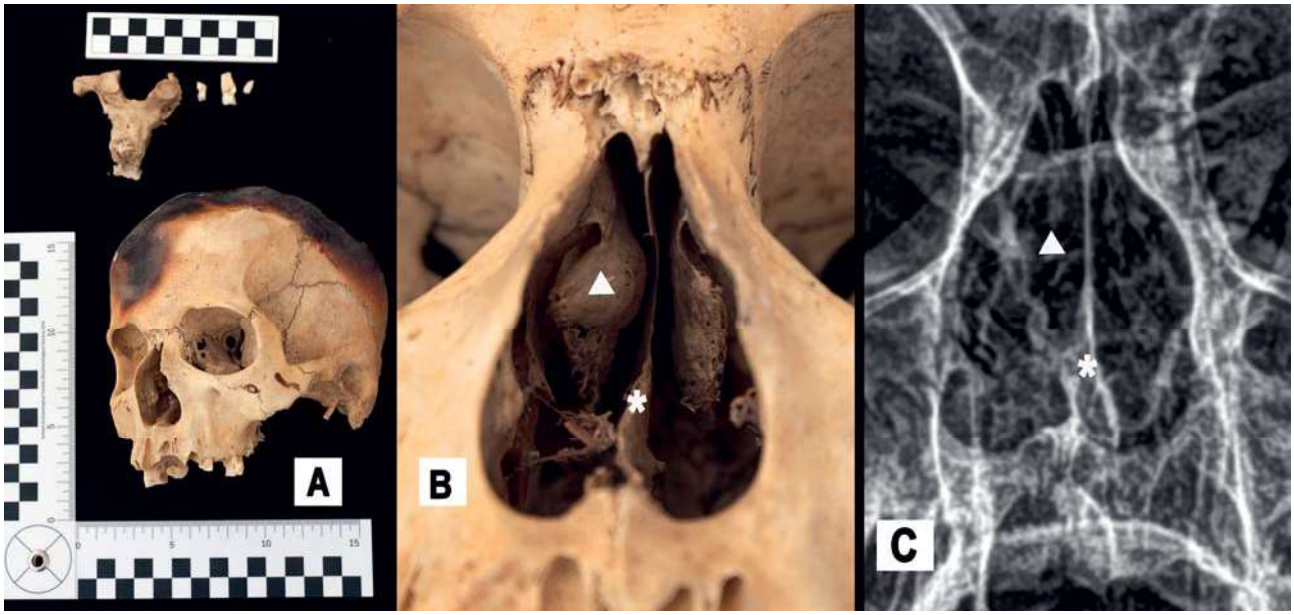

FIGURE 3: [TT16-10.3-BOX01-Ind01]. A, Skull – Fronto-Lateral view. B, Detail of unilateral and bulbous *Concha Bullosa*. C, antero-posterior X-ray image of the nasal area. White triangle shows the middle turbinates, asterisk the nasal septum.

TT12-UE 1188 CRANEO 5713

It is an isolated skull, without his jaw from the excavation of the Djehuty Project (Luxor, Egypt). The skull was found in the southeast chambers of well No. 1192A. This chamber contained fragments of ceramic dating from the 17th–18th Dynasties (1580–1295 CBE). The individual was an adult male (35–49 years). Only three teeth were preserved *in situ* (18, 24 and 25), with several abscesses and an exposed root in tooth 24 (i.e. the mandibular left central incisor). The nasal spine was asymmetric, deviated to the right side (*Figure 4 A, B*; red arrows), with an *antemortem* fracture on the left lateral aspect, causing the nasal cavity to be of different shape and size. In the bones of the nose, signs of an old *antemortem* fracture could be seen, with fusion of the internasal suture in its most anterior third (*Figure 4A*). In the left zygomatic arch, a thrust fracture was found, with the fragment deflected into the into the space towards the temporal fossa (*Figure 4D;* white arrow).

The volume of the right MT was increased in the lower or bulbous portion, with left asymmetry, showing a flat morphology (*Figure 4B, C*). Therefore, it is a *bulbous* CB type. The nasal septum is slightly displaced to the left (Group A; <3°), without clear obstruction of

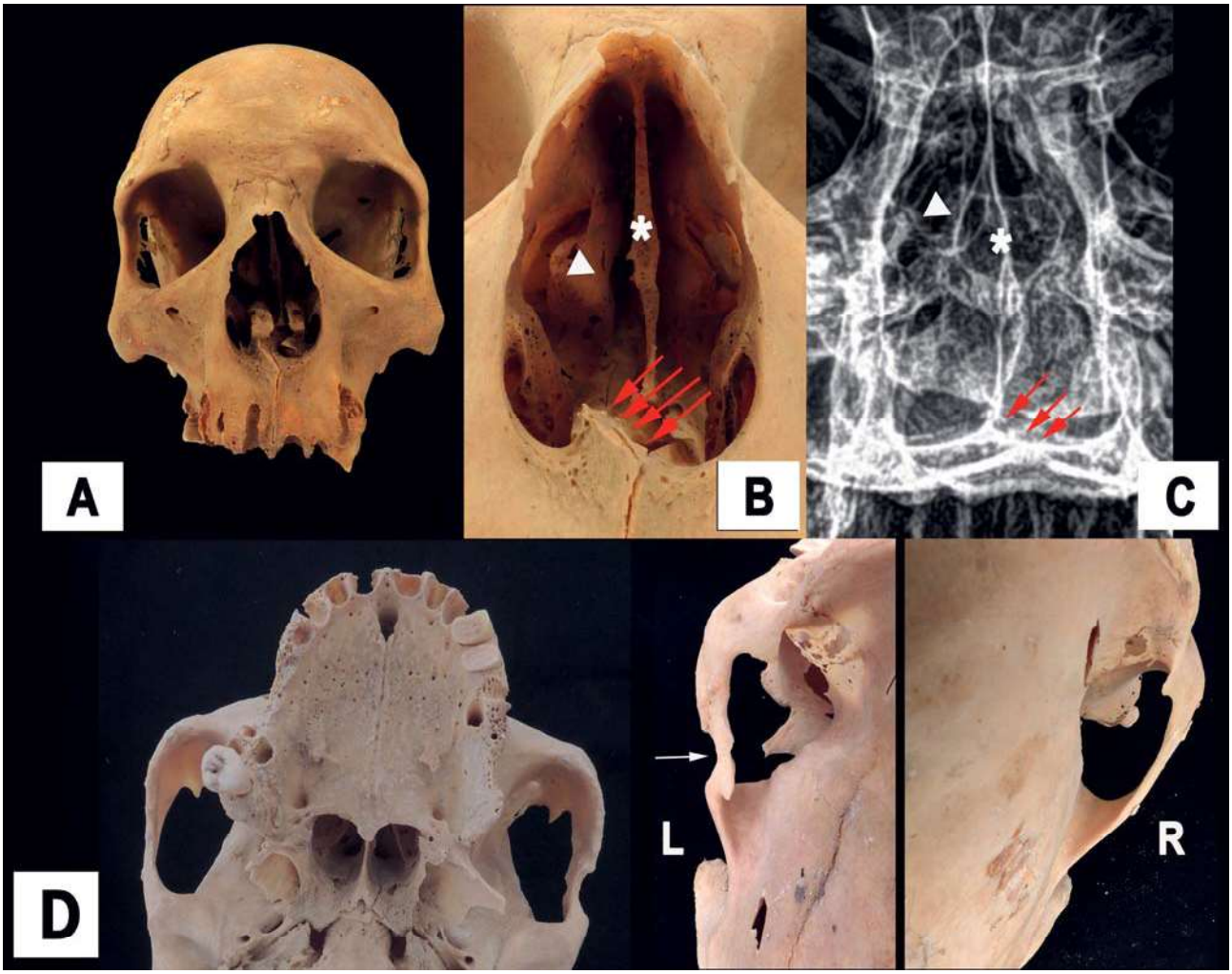

FIGURE 4: [TT12-UE 1188 SKULL 5713]. A, Skull – Frontal view. B, Detail of unilateral and bulbous *Concha Bullosa*. C, antero-posterior X-ray image of the nasal area. Deviation of the nasal spine, with a fracture callus (red arrows). Asymmetry of the nostrils. D, Inferior view: presence of a thrust fracture (white arrow) in the left zygomatic arch, with deflection of the bone fragment into the into the space towards the temporal fossa. White triangle shows the middle turbinates, asterisk the nasal septum.

the nasal meatus, with decrease in the left sinus space (***Figures 4B, C***). There was no presence of new bone formations on the surface of the turbinate, nasal cavity or paranasal sinuses.

DISCUSSION

The different etiologies for of the MT include fibrous dysplasia, neoplasia, and CB (Mays *et al.* 2019). Fibrous dysplasia is the most frequent cause of deformity in the craniofacial region and is considered a hamartomatous process of unknown etiology, which can affect skeletal bones in a monostotic (isolated involvement of a single bone) or polyostotic (involvement of various bones) (Brannon, Fowler 2001, Herrerín *et al.* 2007, Herrerín *et al.* 2009, Mas-Pascual *et al.* 2009). Monostotic fibrous dysplasia can affect the MT (Alba *et al.* 2002, Saetti *et al.* 2004), but the characteristic fibrous bone was not present in the skulls described here (Mays *et al.* 2011). The radiographic images are not the typical clear glass images of fibrous dysplasia (Herrerín *et al.* 2007, Herrerín *et al.* 2009).

A benign neoplastic process can also cause hypertrophy of the MT, in the case of a hemangioma (Caylakli *et al.* 2004) or an ossifying fibroma (Galvan *et al.* 2007, Caylakli *et al.* 2004). However, when this happens, bone growth is not pneumatized, but hyperostotic (Caylakli *et al.* 2004, Galvan *et al.* 2007, Mays *et al.* 2014). The presence of an empty cavity inside the MT, in the radiographic images, is seen in the three cases described. Therefore, CB is the most plausible diagnosis, *extensive* (Case 1) and bulbous (Cases 2 and 3).

The first description of MT pneumatization was by Giovanni Santorinus (Santorini 1724) in his *Observationes Anatomicae*, although Zuckerkandl (1882) coined the term *Concha bullosa*. The etiology is highly controversial (Zinreich *et al.* 1988, Unlü *et al.* 1994). The turbinates appear in the third and fourth months of fetal life and continue to grow after birth until reaching their final size at 12 years of age (Anderhur *et al.* 1992). MT pneumatization occurs as part of the normal development of the ethmoid labyrinth from this age on (Uzun *et al.* 2014).

The deviation of the septum is not the etiology of CB (Uygur *et al.* 2003), although it does increase the pneumatization of the MT (Uygur *et al.* 2003), both in children and in adults (Uzun *et al.* 2014). In cases of symmetric bilateral CB, the septum remains in its correct position, but in cases of unilateral involvement deviated towards the opposite side of the location of the CB (Uzun *et al.* 2014).

Some authors consider CB a good indicator of response to irritants, such as dust, humidity or extreme temperatures (Isidro, Malgosa 2003). Roberts (2007) relates the poor air quality in populations exposed to pollution and toxic agents, such as mines or workshops, with the presence of bone alterations in the nasal area. Other authors have highlighted the relationship between a low economic level and the urban environment, with the incidence of respiratory diseases, even in paleopathological studies (Roberts 2007, Gawlikowska-Sroka *et al.* 2013). A less frequent degree of pneumatization is seen in cold climates (Koertvelyessy *et al.* 1972), but not universally agree (Earwaker *et al.* 1993).

Therefore, the small number of cases described in Ancient Egypt may seem surprising.

If we take into account the hot and dry climate of Egypt, in addition to an air loaded with suspended dust due to the desert, we should expect a greater number of cases described, considering the large number of studies performed for more than a century. For example, in a study carried out with 84 adult skulls from the Roman Period, found in the tomb of Montemhat (TT34, Luxor, ancient Thebes), no case of CB was found (Herrerín, Carmenate 2022), although many of them were excerebrated via the nasal route, which could constitute a limitation when trying to identify it.

This small number of cases described must be related to some mummification practices carried out during much of the history of Ancient Egypt, which included the extraction of the brain through the nasal passages and the ethmoidal cribriform plate, destroying all nasal structures. Internal affairs that were in their path. On the genetic component in the origin of CB, Chaiyasate *et al.* (2012), in a study on CB in twins, found the presence or absence of CB in both monozygotic siblings in 70% of cases, while in dizygotic twins only 25%. The origin of CB has also been proposed as an allergic-type bone response (Gregg, Greeg 1987).

Different clinical studies estimate the range of CB in children between 4.2% and 63.9% (34.54–56), while in adults it would be between 14% and 80% (Bolger *et al.* 1991, Anderhuber *et al.* 1992, Unlü *et al.* 1994, Uygur *et al.* 2003, Uzun *et al.* 2014, Sánchez Fernández *et al.* 2000).

The symptoms associated with CB include, among others, frontal headaches, postnasal obstruction and maxillary sinusitis, as well as a higher frequency of polyps (Stammberger 1986, Stammberger 1991). Nasal obstruction, olfactory disorders, eustachitis, snoring, pharyngitis, laryngitis, and deviation of the nasal septum

are also included among its consequences (Stammberger *et al.* 1990, Cuesta 2008). Of special interest is its possible relationship with chronic sinusitis, proposed by various authors (Bolger *et al.* 1991, Cohen, Matthews 2008, Baxarias 2008) and questioned by others (Mays *et al.* 2014, Kaygusuz *et al.* 2014, Wardani *et al.* 2017, Kalaiarasi *et al.* 2018). A relationship does seem to be proven when the pneumatization of the turbinate and the contact between the mucous "membranes" (Scribano *et al.* 1997).

Most of the cases reported in the paleopathological literature are case reports. Population-based works on archaeological material are very scarce and the frequency of CB is lower than in published studies on current cases (Galassi *et al.* 2024). Mays and colleagues (Mays *et al.* 2014), studied 360 adult individuals from Wharram Percy (Medieval English site), finding 45 skulls possibly affected (12.5%). Also from Medieval times, Pospíšilová and colleagues (Pospíšilová *et al.* 2001), found CB in 52% of the skulls excavated at Broumov Ossuary. On the other hand, Gawlikowska-Sroka and colleagues (Gawlikowska-Sroka *et al.* 2016), found CB in 6.2% of the individuals studied (2 cases out of 32 adult) in a sample from the Predocice cemetery (Poland), from the 19th–20th century.

Therefore, the frequency of CB in the past seems lower than in the present (Bolger *et al.* 1991, Anderhuber *et al.* 1992, Unlü *et al.* 1994, Hatipoglu *et al.* 2005). This assumption does not seem to correspond to the actual data. The study of sinonasal affections in human remains presents important additional difficulties, derived in the first place from the great fragility of these nasal structures (Roberts *et al.* 2007, Cuesta *et al.* 2008, Gawlikowska-Sroka *et al.* 2016), easily damaged both taphonomically and during the removal of material at the time of the anthropological examination (Mays *et al.* 2011, Mays *et al.* 2014).

It is also possible that the little knowledge of these pathologies by anthropologists and paleopathologists, is due to the few published cases, and may go unnoticed (Mays *et al.* 2011). Finally, given that conventional radiography images of these structures can be missed due to overlapping images (Calhoun *et al.* 1991), the use of CAT scan is highly recommended for a correct diagnosis. Unfortunately, access to this procedure is very limited, among other factors, including costs.

CONCLUSIONS

CB is considered an unusual finding in the paleopathological literature. The poor preservation of the nasal area, the lack of knowledge of this pathology and the costs to study at the tomb site, may be the factors of its discrepancy, especially if we compare with current clinical studies. These three cases described from the necropolis of Dra Abu-el-Naga, located on the west bank of the Nile River, in Luxor (ancient Thebes), from different periods, but all more than 2,000 years old, can shed light on this forgotten pathology. The described findings in these three ancient Egyptian skulls lead us to a diagnosis of CB, without signs of infection. More population archaeological studies would be needed to determinate the prevalence of CB in different historical societies, and contribute to the knowledge of the factors influencing the pneumatization of the MT, such as its possible genetic inheritance, sex, age, social status, irritant agents (such as dust, humidity or extreme temperatures) or pollution (related, for example, to work in mines or workshops), including the presence of abundant dust in the air, as it happens in the desert environments, such as Ancient Egypt.

ACKNOWLEDGMENTS

We are grateful to José M. Galán, Director of the Djehuty Project and Suzanne Onstine, Director of the Paneshi Project. Francisco Bosh-Puche for his meticulous excavation and documentation, Zulema Barahona for her work on the ceramics, Joan Ivars for the detailed plans, Monica Ruiz Alonso for her study of the woods and Javier Trueba and Virginia Reckard for their graphics. **Funding**. This article is part of the research project HAR2017-88671-R, part of the Spanish National Program for Scientific Research, Technology, and Innovation. **Conflict of interest.** The authors declare that they have no conflict of interest. No medical writer or editor was involved in the process. No copyright-protected material was used. No medical consent was needed from this over 2,000-year-old patient.

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