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Research article

Differentiating between rhinosinusitis and mastoiditis surgery from postmortem medical training: A study of two identified skulls and hospital records from early 20th century Coimbra, Portugal

Bruno M. Magalhães*, Célia Lopes, Ana Luísa Santos

CIAS (Research Centre for Anthropology and Health), Department of Life Sciences, University of Coimbra, 3000-456 Coimbra, Portugal

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ABSTRACT

Differentiating between medical procedures performed antemortem, perimortem or postmortem in skeletal remains can be a major challenge. This work aims to present evidence of procedures to treat rhinosinusitis (RS) and mastoiditis, suggest criteria for the diagnosis of frontal sinus disease, and frame the individuals described in their medical historical context. In the International Exchange collection, the skull (878) of a 24-year-old male, who died in 1933 due to frontal sinusitis and meningitis, presents evidence of a trepanation above the right frontonasal suture, and micro/macroporosity on the superciliary arches. The available Coimbra University Hospitals archives (1913–1939) reported that 46 females and 59 males (aged 15 months–84 y.o., $\bar{x}$ = 35.33) underwent surgery to treat RS, primarily by trepanation (94.3%). In a search for similar evidence in the collection, the skull of a 42-year-old female (85), who died in 1927 due to sarcoma in the abdomen, shows four quadrangular holes located above the right supraorbital notch, right and left maxilla, and left mastoid process. The number/location of the holes and cut marks point to postmortem medical training (possible dissection). This paper discusses the value of information from historical contexts to differentiate between surgery and medical training in the paleopathological record.

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1. Introduction

Rhinosinusitis (RS) is a group of diseases defined by inflammation of the mucosa of the nose and paranasal sinuses and, depending on the duration of the symptoms, can be defined as acute (<12 weeks) or chronic (≥12 weeks) (Fokkens et al., 2012; Jackman and Kennedy, 2006; Magrysí et al., 2011). Currently, RS is one of the diseases that most commonly affects the respiratory tract (Roberts, 2007; Slavin et al., 2005), and the action of viruses, bacteria and fungi play an important role in its etiology, with exposures to poor air quality in the environment, ciliary impairment, and allergy being the most common factors associated with RS (Dykewicz and Hamilos, 2010; Fokkens et al., 2012; Magrysí et al., 2011). Nevertheless, its true prevalence is unclear, since not all individuals seek care, and because there is a deficit of epidemiological studies exploring its prevalence (File, 2006; Fokkens et al., 2012). RS symptoms can be disabling and lead to significant impairment of quality of life. Major signs and symptoms associated with the diagnosis of chronic RS are facial congestion, pressure and pain, reduction or loss in sense of smell, nasal polyps, nasal obstruction and discharge, and mucosal changes within the osteomeatal complex and/or sinuses (e.g. Caroline et al., 2011; Clement, 2006; Fokkens et al., 2012; Schalek, 2011). RS may include several complications, such as mucocoele formation, orbital cellulitis and abscess, meningitis, intracranial abscess, thrombophlebitis and cavernous sinus thrombosis or perivascular spread of infection (e.g. Madani and Beale, 2009).

Studies in past populations have demonstrated the existence of sinonasal maxillary bone changes with quite diverse frequencies (4%–73.7%) (e.g. Panhuysen et al., 1997; Roberts, 2007). Panhuysen et al. (1997) studied three medieval groups of skeletons from the Netherlands and found no significant differences in maxillary RS between rural and urban populations. Roberts (2007) compared data from three continents and found, with few exceptions, a lower susceptibility to maxillary RS in hunter-gatherers, people who lived in a rural environment, or who had a high status. To the authors' knowledge, trepanation of the maxillary sinuses is unknown amongst the evidence of surgical treatment in bioarchaeological contexts, while few surgical procedures are reported on frontal antra (Table 1).

* Corresponding author.
E-mail address: bruno.miguel.silva.magalhaes@gmail.com (B.M. Magalhães).

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Table 1
Reports of trepanation to frontal sinuses and mastoid processes in paleopathology (ordered by period of time).

Reference	Location	Chronology	Individuals
Frontal sinuses			
Zias and Pomeranz (1992)	Israel	5500 y.o.	One individual[a]
Armentano et al. (1999)	Spain	Chalcolithic/Bronze age	One young female
Burton (1920)	Peru	1200 to 2000 y.o. (?)	Three individuals[a]
Campillo et al. (1999)	Spain	11th to 16th century AD	One young adult, one undetermined
Mastoid processes			
Boljunčić and Hat (2015)	Croatia	11th century AD	One adult male
Vercelotti et al. (2010)	Italy	Late 19th/20th century	Two individuals[a]
Vercelotti et al. (2010)	USA	20th century	Possibly five individuals[a]

[a] No age and/or sex were specified in these studies.

Mastoiditis is a term used for the presence of inflammation of both the mucous membrane in the pneumatized mastoid cells and the underlying bone tissue (Flohr and Schultz, 2009a, 2009b; Palma et al., 2014). It can be defined as acute or chronic, and is a consequence of otitis media, typically caused by the invasion of bacteria through the Eustachian tube into the tympanic cavity (Flohr and Schultz, 2009a, 2009b; Palma et al., 2014). Flohr and Schultz (2009a) identified bone alterations associated with mastoiditis in 83.4% of human skeletal remains from two early medieval German cemeteries, but with the introduction of antibiotic therapy, mastoiditis became a rare consequence of otitis media in the industrialized world, although it is still common in developing countries (e.g. Tarantino et al., 2002; Vassbotn et al., 2002).

Several studies have described osseous changes associated with ear infection in past populations (Flohr and Schultz, 2009a, 2009b; Mann et al., 1994; Mays and Holst, 2006), essentially, distinct plate-like osseous proliferations attached to the walls of the pneumatized cells of the inner part of the mastoid process; pin-like or spicular structures; and complete filling in of the pneumatized cells with bone, or fine net-like bone formation (Flohr and Schultz, 2009a, 2009b). Upper respiratory tract infections are known to play a role as a causative/complicating factor of otitis media in clinical literature, and the risk for otitis media may be reduced when exposure to viral respiratory infections is avoided (e.g. Chonmaitree et al., 2008; Nokso-Koivisto et al., 2015; Revai et al., 2007). Unfortunately, this possible relationship is unknown in past populations, due to the lack of studies. Knowledge of surgery to relieve mastoid process infection in the past is also rare. Despite documentation of mastoidectomies in clinical studies since the 16th century (Bento and Fonseca, 2013), only a few examples have been described in paleopathological literature (Table 1). The reasons why this is a reality are not very clear but the need for specific anatomical and surgical knowledge in the past, poor preservation of the frontal and maxillary bones and mastoid processes in archaeological contexts, or the lack of interest of anthropologists to investigate these particular cases in identified samples may be pointed out as possibilities.

Distinguishing among medical procedures performed antemortem, perimortem, or postmortem using dry bones can be very difficult, and this is frequently highlighted in forensic pathological studies on trauma (Cappella et al., 2014; Fleming-Farrell et al., 2013; SWGANTH, 2011; Ubelaker, 2015; Wheatley, 2008). In fact, in the last few years the 'perimortem concept' has been discussed within the anthropological sciences as determined on the basis of evidence of the biomechanical characteristics of the plastic response of fresh or green bone or through the detection of specific mechanisms causing injuries (blunt or sharp force), not taking into account the death event itself (SWGANTH, 2011; Ubelaker, 2015). Although evidence of surgery is well documented in paleopathological studies (e.g. Carty, 2013; Powers, 2005; Santos and Suby, 2015), it can be difficult to accurately diagnose when performed close to the death of a patient (e.g. Dittmar and Mitchell, 2015; Santos and Suby, 2015) before bone start remodeling, and thus may be confused with postmortem medical examinations such as autopsy, dissection, and prosection. To distinguish between these procedures can also be challenging, because all of them take place after the death of the individual. Autopsy refers to an examination whose purpose is to determine the cause of death, while the primary aim of dissection is to facilitate the anatomical study of the human body by students (Bugaj et al., 2013; Nystrom, 2011). Dissection is distinguished from prosection, the latter of which being performed by an experienced anatomist while the student learns by observing (Yeager, 1996). Postmortem medical examinations have been reported mostly in Europe (e.g. Boston and Webb, 2012; Bugaj et al., 2013; Dittmar and Mitchell, 2015; Fornaciari et al., 2008) and in the United States (e.g. Nystrom, 2011).

This research aims to present evidence of medical procedures during the first half of the 20th century in Coimbra (Portugal), suggest lesions that can identify possible frontal sinus disease, and frame the individuals studied within their medical historical context.

2. Material and methods

The individuals studied belong to the International Exchange Skull collection curated by the University of Coimbra. This osteological collection is composed of 1142 well preserved skulls, representing 578 females and 564 males, with ages at death ranging from 6 to 109 years old ($\bar{x} = 46.22$). All died in Coimbra between 1904 and 1937, were buried at the Municipal Cemetery of Conchada, and have documented identifications (sex, age at death, birthplace, occupation, address, and cause of death) (Lopes, 2014; Rocha, 1995; Santos, 2000).

The applied methodology included several steps. Firstly, signs of medical procedures on the frontal and maxillary bones and the mastoid processes were macroscopically explored, and evidence of trepanation and cut marks caused by surgical instruments was recorded. The dimensions of all cut marks were measured with the use of a sliding caliper. Evidence for the four types of bone response (osteoblastic, osteoclastic, line of demarcation, and sequestration) described by Barbian and Sledzik (2008) for cranial trauma was also macroscopically explored, with the assumption that the bone response would be similar for both antemortem medical procedures and trauma. In addition, considerations outlined by SWGANTH (2011) and Ubelaker (2015) for perimortem identification were taken into account. Finally, the method developed by Dittmar and Mitchell (2015) was considered for better distinguishing human dissection and autopsy. The skulls were observed using strong illumination with a magnifying glass, allowing a more accurate differential diagnosis to be made among antemortem, perimortem and postmortem medical procedures.

A videoscope (Cartull Professional, external diameter of 4.9 mm) was used to look for inflammation within the maxillary and frontal

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