International Journal of Paleopathology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Paleopathology

journal homepage: www.elsevier.com/locate/ijpp

A truncated temporal styloid process from the Jordanian Ottoman Period: Developmental variant or fracture?

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ARTICLE INFO

Keywords:
Eagle's syndrome
Stylohyoid complex
Elongated styloid process
Styloid process fracture
Stroke

ABSTRACT

Styloid process (SP) development and its role in an individual's lived experience plays a negligible role in paleopathological research, although a handful of possible Eagle's syndrome cases have been reported. Here, the development of the stylohyoid chain and the medical research of SP variants are reviewed to inform the differential diagnosis of a probable SP fracture in a young adult male associated with the Ottoman Period (13–19th C) in Jordan. The fracture surface of the right SP is smooth rather than irregular, the coloration is uniform with the surrounding cortical bone staining, and no new bone formation is visible. All features are consistent with a perimortem injury. An unossified stylohyal is a differential diagnosis, while the left elongated SP suggests a predisposition to intrinsic injury. The implications of SP fractures are considered.

1. Introduction

Medical research of temporal styloid process (SP) variability and Eagle's syndrome has increased exponentially with studies derived from radiology and CT-scanning of living patients, as well as cadaver and dry anatomical bone samples (Alpoz et al., 2014; Başekim et al., 2005; Ekici et al., 2013; Margam and Jadhav 2015; Natsis et al., 2015). Gayathri et al. (2016) indicate that while the dry bone studies provide accurate measurements, there is no correlation with symptoms that is achieved when studying living people. Rarer still, is the fractured SP (Babbitt 1933; Miloro 1994), which has often gone unrecognized by clinicians, resulting in extenuating pain and unnecessary medical treatments for the affected individual (Dubey et al., 2013; Miloro 1994; Ramadan et al., 2010; Simmons and Bernstein 1956). Aside from a few forensic anthropological investigations (e.g., Spence et al., 1999; Vougiouklakis 2006), only a handful of paleopathological cases mention the SP (e.g., Dąbrowsk et al., 2015; Fotis et al., 2013; Kilgore and Van Gerven 2010; Mays et al., 2011; Ozdemir et al., 2013; Sawyer et al., 1980; Šikanjić and Vlak 2010). Here, an archaeological case of a probable SP fracture is presented with a review of SP anatomy and development. A differential diagnosis of SP variability and the implications for the individual's life and perhaps death due to an SP fracture are considered.

2. Case description

Individual WT140.3 was excavated during the 2005 field season at Khirbet al-Mudayna, an Iron Age site in Jordan (Fig. 1). The burial site (WT140) was approximately 400 m south of Mudayna and discovered during a pedestrian survey of the Wadi-ath Thamad vicinity (Judd 2007). The burial was located in a bedrock outcrop that exposed a series of shallow crevices, which in the past were attractive burial locations for nomadic groups (Mustafa and Tayeh 2014); these isolated burials are dated to the Ottoman period (13–19th C AD) at Wadi-ath Thamad (Gregoricka and Judd 2016). The excavation revealed an articulated skeleton (WT140.3) 1.25 m below the surface. The skeleton lay supine, but angled slightly to the right; the right lower limb was flexed so that the right leg crossed the left femur at 90° (Fig. 2). Missing elements included 9 left hand bones; 1 left and 4 right ribs; right patella; and 39 foot bones. The right upper limb and hand were not recovered, but may have been shifted by pit vipers nesting and exiting along the rear of the crevice.

The skeleton is male, approximately 24–34 years old at the time of death, with all epiphyses fused. The features of the skull and pelvic bones are clearly male (Buikstra and Ubelaker 1994; Phenice 1969). Pubic casts (Brooks and Suchey 1990) were used to estimate an age-at-death of 24–28 years and the fused medial clavicles suggests an age nearer 31 years (Webb and Suchey 1985). Both estimates fall within the broad age estimate of 16–65 years for the auricular surface (Buckberry and Chamberlain 2002). Stature from the left femur (455.2 mm) is estimated to be 169.74 ± 3.27 cm (5′-7″ ± 1″) (Trotter 1970).

Antemortem tooth loss (AMTL) (Lukacs 1989) is indicated by partially resorbed maxillary alveoli at the right first molar and both second premolar locations. Mandibular alveoli are obliterated at the locations of the first molars, right second molar and left central incisor. All other teeth are present and exhibit little to moderate wear according to Smith's (1984) classification. The tip of the nasal bones project into the

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http://dx.doi.org/10.1016/j.ijpp.2017.08.002
Received 23 May 2017; Received in revised form 24 July 2017; Accepted 1 August 2017

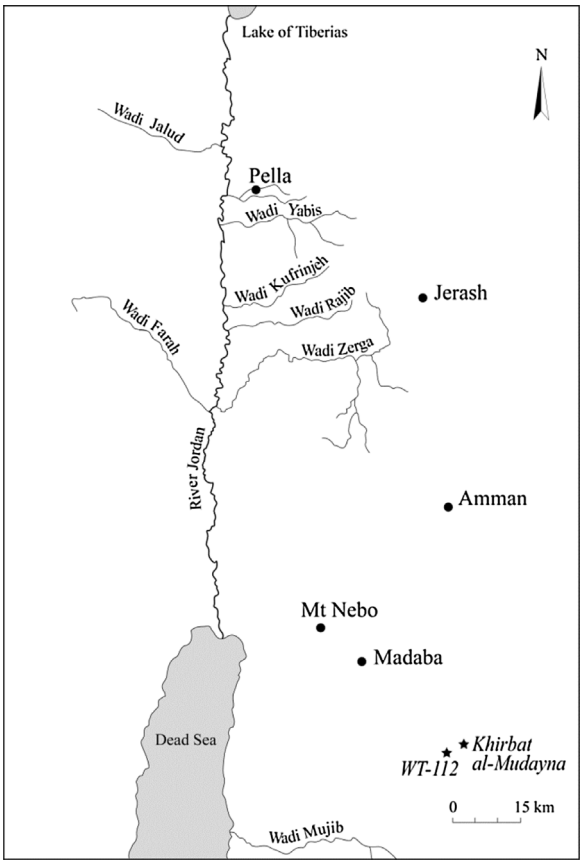

Fig. 1. Map showing the location of Khirbat al-Mudayna, Jordan.

Fig. 2. WT140.3 skeleton *in situ*.

nasal aperture due to a well-healed antemortem fracture. The left proximal foot phalanx has a healed sharp force injury through the head. Several axial anomalies are present: a right paracondylar tubercle articulates with a facet on the right transverse process of the atlas; a posterior ponticle projects from the atlas' right superior articular facet into a fossa posterior to the right occipital condyle; L5 spondylolysis and an incompletely fused S1 spinous process.

Distinguishing between ante-, peri- and postmortem bone breakage is challenging, but necessary for forensic casework and bioarchaeological interpretations of past behavior (e.g., Johnson 1985; Knüsel 2005; Sauer 1988; Slaus et al., 2010; Ubelaker and Adams 1995; Wheatley 2008; Wieberg et al., 2008). Knüsel (2005) summarized the subtle fracture pattern changes resulting from the reduced collagen in dry bone (postmortem) compared to wet bone (perimortem) to provide

Fig. 3. Inferolateral view of the right styloid process.

useful criteria with which to assess the time of fracture relative to the individual's death. These criteria include the discoloration of the fracture margin compared with the exposed cortex, fracture surface texture and fracture outline. For WT140.3, the exposed fracture surface of the right SP is smooth rather than rough, and the fracture outline is more spiral rather than transverse (Fig. 3). The coloration of the exposed fracture surface and margin are uniformly stained with the surrounding cortical bone (Fig. 4). An examination using a 20–50X magnifier with a light attachment revealed no new bone formation that partially or completely obliterated the fracture margin or surface, signaling an antemortem fracture. All features are typical of a perimortem fracture, occurring around the time of death before any significant healing occurs (Knüsel 2005: 53). In comparison, dry bone SP breaks observed among other individuals from this site exhibit color heterogeneity between the exposed surface and cortical bone, a transverse fracture outline, an irregular fracture margin and a rough fracture surface (Fig. 5).

The morphology of the left SP is normal with a pointed apex (Fig. 6). The SP length was measured using Custodio et al.'s (2016) posterior measure, which accords with computed tomography (CT) imaging standards. This posterior measure was taken from the most inferior tip to the surface beside the stylomastoid foramen to produce a length of 31.3 mm for the left and 14.3 mm for the right SP.

3. Discussion

3.1. Stylohyoid development and anatomy

The stylohyoid chain (SHC) is essential for mastication, tongue movement and swallowing (Başekim et al., 2005). The SHC consists of the styloid process (SP), stylohyoid ligament (SHL) and superior hyoid body (lesser cornua), and is formed from Reichert's cartilage of the second pharyngeal arch (Dwight 1907). The SHC has four developmental centers. The proximal segment (tympanohyal) is the base of the SP, which is ensheathed by a vaginal process and articulates with the tympanic plate. The second segment (stylohyal) is a long 'needle-like' projection that anchors the third segment, the stylohyoid ligament (originally the ceratohyal), which inserts distally into the lesser cornua (hypohyal) of the hyoid, the fourth segment (Dwight 1907; Rechtweg and Wax 1998). The anatomical SP is formed by two segments only: the tympanohyal and stylohyal. For the majority of individuals, a partially ossified tympanohyal is present at birth, while the stylohyal begins to ossify after birth. They continue to ossify and normally unite at about 5–8 years to form a slender cylindrical bony projection, but in many individuals one or both of these segments may never ossify (Başekim et al., 2005; Krmpotić Nemanić et al., 2008; MacDonald-Jankowski 2001; O'Carroll 1984).