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## Anatomical and radiological notes on the sternum of Sicily's earliest known woman (San Teodoro Cave, Messina, Palaeolithic Period, 14,500 BP)

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**Abstract.** In this brief anatomical and palaeopathological communication the authors detail the characteristics and alterations noted on the sternal body and xiphoid process of ST1, Sicily's earliest known female skeleton, dated to the Palaeolithic Period (14,500 years BP). A morphological and radiological analysis is offered both in terms of the relation between age and manifestation of the xiphisternal fusion, with a focus on ancient traumatology involving the soft tissues near the sternum to explain calcification of xiphoid and, more likely, the local presence of an exostosis.

**Keywords:** anatomy, anthropology, heterotopic calcification, radiology, sternum, xiphoid process.

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### INTRODUCTION

The San Teodoro Cave (*Grotta di San Teodoro*, Acquedolci, Messina, North-Eastern Sicily) has been the subject of considerable anthropological, zooarchaeological and ecological interest ever since its first exploration by Baron Francesco Anca di Mangalaviti (1803-1887) in 1860 since it represents the earliest known evidence of the peopling of the Mediterranean island of Sicily. This site (Fig. 1a,b) became even more interesting when, from 1937 on, human skeletons started to be excavated leading to the discovery of remains of seven individuals (ST1 to ST7). Individuals ST1-5 were described by Graziosi in 1947 (Graziosi 1947), while the fragmentary remains of the skull of ST6 were later described by Pardini in 1975 (Sineo et al. 2002; D'Amore et al. 2009). In 1989, Aimar and Giacobini published their skeletal assessment of ST7 (Sineo et al. 2002; D'Amore et al. 2009), whereas, in 1993, Fabbri pro-

posed a morphometric revision of sex and stature of ST1 and ST4 (Fabbri 1993). In this research we focused on ST1, a young adult individual (originally considered to be male based on the cranial morphology, later proposed to be a female based on pelvic morphology), radiocarbon-dated to 14,500 BP, whose osteological remains (Fig. 1c) are currently exhibited in Palermo's G.G. Gemmellaro Museum of Palaeontology. At present, a novel thorough multidisciplinary reassessment of the skeletal remains of this individual – popularly nicknamed “Thea” – is taking place under the scientific leadership of the University of Palermo (Prof. L. Sineo). In the context of this global analysis, special attention has been paid to ST1's thorax and especially the morphology of her sternum by offering an anatomical and radiological perspective.

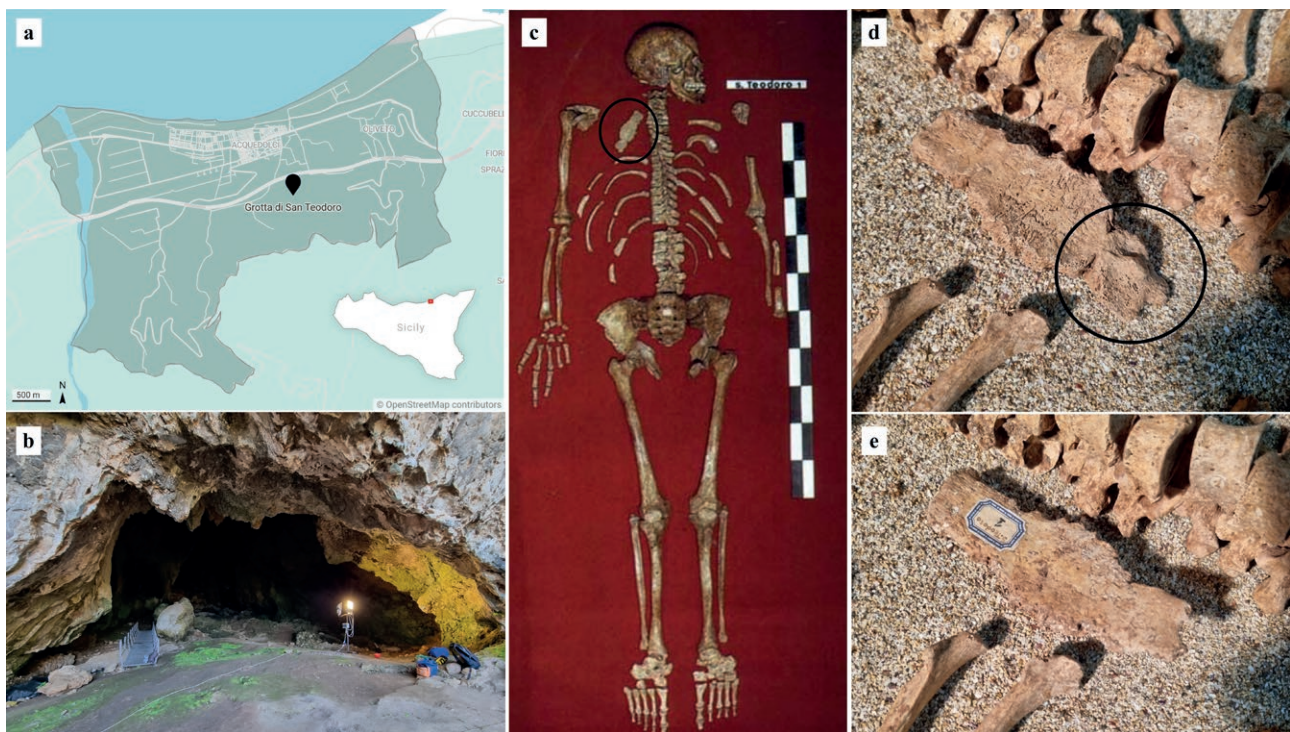
## MATERIALS AND METHODS

The sternum, which could be assessed through direct visual inspection in the said museum, only consisted of the body of the sternum and the xiphoid process, while the manubrium was not available for this study since it

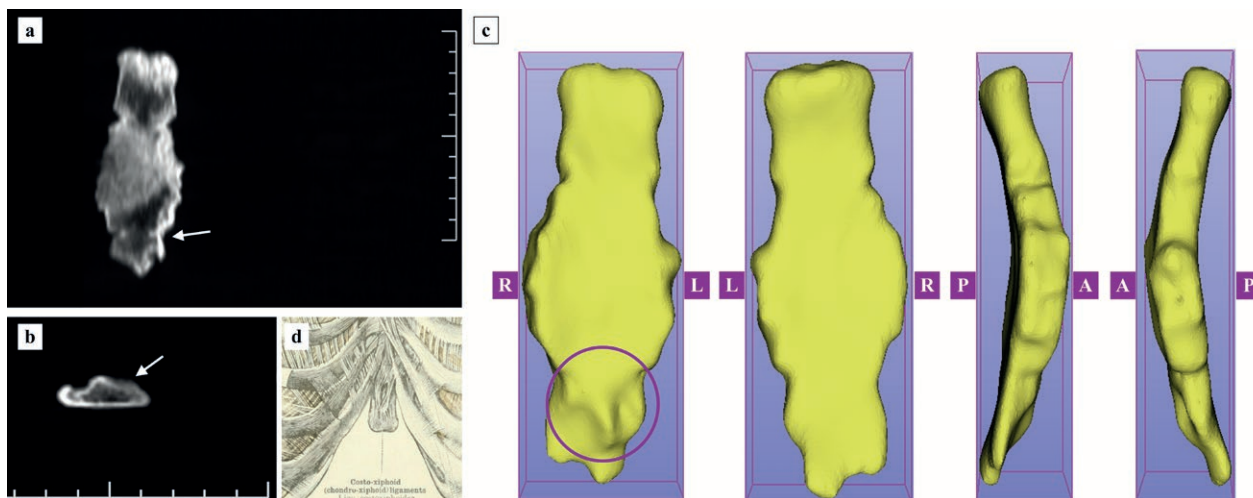
has not yet been “repatriated” to Sicily to this date and is still currently housed in the Florentine Museum and Institute of Anthropology. Beside the gross morphological examination, the study was complemented by Computerised Tomography (CT) scan imaging analysis and a 3D digital reconstruction. CT scanning of the sternum was performed using a General Electric LightSpeed VCT 64 Slice CT multidetector scanner with a gantry rotation time of 0.6 s, a slice thickness of 0.625 mm, and maximum intensity projection for integration. Images were saved (as bitmap files) in Digital Imaging and Communications in Medicine format and processed, visualised, and segmented using the open-source software 3D Slicer (Fedorov et al. 2012). Finally, a differential diagnosis has been proposed and an anatomical contextualization presented as is customary in palaeopathological studies (Buikstra 2017; Galassi et al. 2020; Varotto et al. 2021).

## RESULTS

ST1's sternum, in both the anterior and posterior views (Fig. 1d,e), shows a complete synostosis of the xiphi-



**Figure 1.** a. The geographical position of the San Teodoro Cave in the territory of the municipality of Acquedolci (province of Messina, Sicily) – map made by coauthor E.V. with Datawrapper ([www.datawrapper.de](http://www.datawrapper.de)); b. The entrance of the cave during scientific explorations (image by co-author and project leader L.S.); c. ST1's skeleton displayed in the G.G. Gemmellaro Museum of Palaeontology (Palermo, Italy), with the sternum highlighted by a black circle – image by the Museum in the public domain; d. anterior view of ST1's body and xiphoid process. The investigated structure lies within a black circle; e. posterior view of the sternum.



**Figure 2.** a. Coronal and b. transverse sections of ST1's sternum (ST1's sternum) – white arrows indicate the investigated structure; c. the four views (left to right of the image: anterior, posterior, right lateral and left lateral) of the sternum in a 3D digital reconstruction. The purple circle in the first image highlights the heterotopic calcification and exostosis; d. schematic anatomy of the ligaments of the human sternum from C. Told's *An Atlas of Human Anatomy for Students and Physicians* (1919), copyright expired.

sternal joint and, even more patently in the anterior view (Fig. 1d) a heterotopic calcification of the entire xiphoid process. Additionally, the anterior surface of the sternum (Fig. 1d) shows an uncommon outgrowth of bone that can be appreciated perpendicularly to the coronal plane. This evidence is corroborated by the computed tomographic examination of the internal bone structure (Fig. 2a,b). A 3D digital reconstruction of the fused sternal body and xiphoid process was provided in the four views (Fig. 2c).

## DISCUSSION

With reference to the xiphisternal fusion, it has been observed that it starts between 30 and 39 years of age and can be confidently used to predict age at death in forensic anthropological studies (Partido Navadizo & Alemán Aguilera 2022). This could partly be compatible with the ST1's estimated age category as the young adult one (20-35 yrs) but it should be underlined that this phenotype can be either the result of a congenital anomaly or merely a normal manifestation during an individual's growth.

Moreover, with reference to the described exostosis emerging from the heterotopic calcification of the xiphoid process, through the CT scan analysis, it was possible to exclude that it was the result of the healing process following a bone fracture because of the absence of fracture lines or of a congenital anomaly, since no cases with a comparable morphology and topography are known to have been reported so far.

For this reason, a soft tissue trauma cannot be excluded *a priori* from the potential aetiologies in question. This scenario could indeed be compatible with a subsequent heterotopic calcification of the chondroxiphoid ligaments (Fig. 2d), which is nonetheless more rarely observed in individuals under 45 years of age (Duraikannu et al. 2016), it being very rare in 20-year-olds – and in the present-day clinical setting occasionally seen only after locoregional surgery (Hong et al. 2016).

## CONCLUSIONS

The simultaneous presence of synostosis of the xiphisternal joint with evidence of a heterotopic calcification of the whole xiphoid process and the contextual heterotopic calcification of the chondroxiphoid ligaments in a young adult such as ST1 represents an element to be considered in the general state of health of Sicily's earliest known woman and a valuable insight into the evolution and adaptation of sternal anatomy to palaeotraumatological events in past human individuals, well before the dawn of civilisation and the birth of thoracic surgery.

While future research could be directed at the assessment of sternal morphologies, both normal and pathological, in a larger Sicilian and Italian skeletal sample, this study's immediate goal is also to assist researchers in distinguishing age-related calcification of skeletal tissue from the secondary effects of soft tissue trauma.

## ACKNOWLEDGMENTS

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