

Sexual dimorphism of the Middle Pleistocene hominins from Sima de los Huesos (Burgos, Spain): a study the enamel and dentine dimensions of the permanent canines

Cecilia García-Campos^{1,2}, Mario Modesto-Mata^{1,2}, María Martín-Torres^{1,2}, Marina Martínez de Pinillos^{1,2}, Laura Martín-Francés^{1,3}, Juan Luis Arsuaga⁴, José María Bermúdez de Castro^{1,2}

1 - Centro Nacional de Investigación sobre la Evolución Humana, Burgos, Spain · 2 - Anthropology Department, University College London, London, UK · 3 - Université de Bordeaux, CNRS, MCC, PACEA, UMR 5199 F - 33615, Pessac Cedex, France. · 4 - Centro Mixto UCM - ISCIII de Evolución y Comportamiento Humanos, Madrid, Spain

Sexual dimorphism, as an important part of the total variation seen in populations, plays a key role in taxonomic debates. In this context, Sima de los Huesos (SH) hominins, from Sierra de Atapuerca in Spain, offer an exceptional opportunity to investigate within-population variability. For this reason, these fossil remains have been used in previous research to study sexual dimorphism during the Middle Pleistocene [1,2,3,4]. However, all these studies have had to face the same limitation: this exceptional human collection has a predominance of adolescents and prime-age adults [1]. In modern humans, most of the dimorphism in body size is generated during adolescence; nevertheless, intersexual variation in dental crown size is generated between birth and the 12th year [5]. That is why teeth, in general, and canines, in particular, are very useful in assessing sexual dimorphism in extinct populations with SH demographic characteristics. In 1993 and in 2001, Bermúdez de Castro and colleagues studied the pattern of dental size variation of the SH lower dentition [1,2]. Since then, the dental sample of the Middle Pleistocene population from Atapuerca has increased and novel imaging analytical techniques like micro-computerized tomography (micro-CT) have emerged, permitting reanalysis of this issue from a new perspective. In this study, micro-CT techniques have been applied to a sample of hominin teeth from the site of Sima de los Huesos. Dental tissue proportions of the permanent canines are here assessed with the aim of characterizing the pattern and degree of sexual dimorphism within this population. A combination of classical statistical approaches with more novel ones has allowed us not only to bolster the sex allocation of the individuals previously assigned in the literature, but also to estimate the sex of the youngest individuals, which were not assessed in previous studies. Likewise, the sex of some extensively worn canines and isolated pieces has been also estimated. As a result, the sex ratio observed in our dental sample from Sima de los Huesos population is 5:8 (Nm:Nf), showing a higher female representation. The canines of Sima de los Huesos population have, in general terms, a degree of sexual dimorphism in the permanent canines tissue proportions that is lower or similar to that of modern humans. Their mandibular canines are more dimorphic than the maxillary ones among other things, due to the marked dimorphism of their root dimensions. In light of our results, we can conclude that this European Middle Pleistocene population cannot be considered more dimorphic than modern humans, although the differences in their canine tissue proportions are enough to allow estimating the sex with a high degree of confidence. One reasonable interpretation of our results would be that the sexual dimorphism of dental tissue patterns could have already decreased during Middle Pleistocene regarding early Homo, and was maintained, to either greater or lesser extents, in subsequent groups. However, this decrease in intersexual variability may have not happened at the same time in all skeletal structures, showing a mosaic evolution of the expression of sexual dimorphism in the different bone elements. Future studies of the SH hominins, as well as other European Middle Pleistocene samples, would help to test this hypothesis.

This study has been supported by the Dirección General de Investigación of the Spanish Ministerio de Economía y Competitividad (MINECO) grant number: PGC2018-093925-B-C31. We also wish to acknowledge The Leakey Foundation for the personal support provided by Gordon Getty and Dub Crook (2014-2019) to one of the authors (MM-T). CG-C and MM-M are funded by a doctoral grant financed by the European Social Funds through the Consejería de Educación. LM-F received financial support from the French State as part of the 'Investments for the future' Programme IdEx Bordeaux, reference ANR-10-IDEX-03-02. MMP is the recipient of a post-doctoral research grant at Atapuerca Foundation. We thank all the members of the Atapuerca research team, in particular those who excavate the Sima de los Huesos site, for their dedicated work. We also acknowledge several people for providing access to the studied material.

References:[1] Bermúdez de Castro, J.M., Durand, A.I., Ipiña, S.L., 1993. Sexual dimorphism in the human dental sample from the SH site (Sierra de Atapuerca, Spain): a statistical approach. *Journal of Human Evolution*. 24, 43–56.[2] Bermúdez de Castro, J.M., Sarmiento, S., Cunha, E., Rosas, A., Bastir, M., 2001. Dental size variation in the Atapuerca-SH Middle Pleistocene hominids. *Journal of Human Evolution*. 41, 195–209.[3] Lorenzo, C., Carretero, J.M., Arsuaga, J.L., Gracia, A., Martínez, I., 1998. Intrapopulation body size variation and cranial capacity variation in middle pleistocene humans: The Sima de los Huesos sample (Sierra de Atapuerca, Spain). *American Journal of Physical Anthropology*. 106, 19–33.[4] Rosas, A., Bastir, M., Martínez-Maza, C., Bermúdez de Castro, J.M., 2002. Sexual dimorphism in the Atapuerca-SH hominids: the evidence from the mandibles. *Journal of Human Evolution*. 42, 451–474.[5] Simpson, S.W., Kunos, C.A., 1998. A radiographic study of the development of the human mandibular dentition. *Journal of Human Evolution*. 35, 479–505.