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RESEARCH ARTICLE

An Upper Paleolithic horse mandible with an embedded lithic projectile: Insights into 16,500 cal BP hunting strategies through a unique case of bone injury from Cantabrian Spain

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Abstract

Embedded artifacts in osteoarchaeological remains may be key to approaching hunting strategies and other behavioral-related issues such as technological development. However, that kind of evidence is not common within the archaeological record and often not well-characterized, especially for faunal remains from prehistoric sites. Here, we present and discuss a unique case of a horse (*Equus caballus*) mandible with an embedded lithic remains from the Upper Paleolithic (ca. 17,300–16,200 cal BP) from La Garma cave in Cantabria, Spain. Our macro- and microscopic faunal and lithic integrated analysis suggests that the case presented here is a potential perimortem hunting lesion, representing an uncommon hunting strategy during the Magdalenian period. Furthermore, this study, representing the first case of its kind in the Iberian Peninsula, emphasizes the importance of the taphonomic analysis of bone surfaces to approach the understanding of past human behaviors.

KEYWORDS
archaeozoology, hunting lesion, Iberian Peninsula, lithics, Middle Magdalenian, prehistory, taphonomy

1 | INTRODUCTION

Embedded artifacts in osteological remains, such as lithic or metallic projectiles, are scarce within the archaeological record and are commonly associated with post-Paleolithic human bones and interpretations linked to interpersonal violence (e.g., Crevecoeur et al., 2021; Fernández-Crespo et al., 2023; Mirazón Lahr et al., 2016). However, when a direct association between animal skeletal remains and embedded projectiles is observed, this permits the interpretation of past behavioral aspects such as technological development (e.g., Bratlund, 1991; Leduc, 2014; Letourneux & Pétillon, 2008; O'Driscoll & Thompson, 2014), subsistence strategies (Boëda et al., 1999; Duches et al., 2019; Milo, 1998; Morel, 1999; Münzel & Conard, 2004; Nikolskiy & Pitulko, 2013; Wojtal et al., 2019), and taphonomic processes (Marginedas et al., 2024).

Current research, influenced by the development of methodological microscopic analysis (i.e., environmental scanning electron microscope [ESEM] and stereomicroscopic analysis), has permitted the recognition of an increasing number of embedded projectiles, mainly lithic arrowheads (see Table S1 and Figure S1 and cases cited therein). In addition, actualistic experimental protocols have provided useful referential frameworks to distinguish between butchery-related modifications and Projectile Impact Marks (PIMs) (see Duches et al., 2020, 2016; Lewis, 2008; O'Driscoll & Thompson, 2014; Smith et al., 2020), including hunting lesions even when an embedded element is not present (Gaudzinski-Windheuser et al., 2018). However, this is a critical methodological issue given that unless a projectile is preserved, the remaining modification may be confused with tool processing marks or taphonomic damage, including carnivore modifications (Gaudzinski-Windheuser, 2016).

Here, we present a unique case of a potential embedded lithic arrowhead from a Magdalenian archaeological site from the Iberian Peninsula, contributing to the understanding of Paleolithic hunting strategies. The case study discusses the association between a flint embedded artifact on the internal (i.e., lingual) surface of a horse (*Equus caballus*) mandible from La Garma (Cantabrian Spain) and its past socioeconomic implications. The study characterizes the lithic element, its position in relation to the animal anatomy, and the bone surface marks observed with the aim of contributing through an osteoarchaeological analysis to the reconstruction of specific, not well-documented Upper Paleolithic hunting strategies.

2 | MATERIALS AND METHODS

2.1 | The archaeological context

The archaeological complex of La Garma is located in a karstic system from the central area of the Cantabria region in Northern Spain, 6 km from the current seashore (Figure 1). The system is formed by 12 karstic levels with at least seven entrances. The bone specimen discussed here was found in La Garma A, one of the cavities located 86 m above sea level, providing the only practicable access to the inner karst system. This cavity consists nowadays of a hall and a chamber connected by a narrow passage (Figure 2) and filled with a stratigraphic sequence ranging from the beginning of the Upper Paleolithic (38,000 cal BP) to the Middle Ages. The item discussed here comes from layer L, corresponding to the Middle Magdalenian and radiocarbon dated between 17,300 and 16,200 cal BP. Due to slight grain size variations, the layer was divided into four units, with sublayer L3 being the one where the bone specimen discussed here was discovered. This layer is 6.6 cm thick in the vestibule area and geologically defined by yellowish silt and limestone pebbles. A C^{14} date from L3 provides a result for sublayer of 13,810 ± 180 BP (AA 45577), calibrated as 17,296–16,247 cal BP [95.4%, calibrated with OxCal v.4.4.4 program (Bronk Ramsey, 2021) and IntCal20 atmospheric curve (Reimer et al., 2020)].

The analysis of layer L3 has allowed us to distinguish different activity areas (Arias et al., 2005), including a passage zone with a low frequency of highly fragmented remains. In this area, knapping activities were conducted, although most of the human activity is concentrated in the inner area of the cavity given the remains excavated.

2.2 | Osteoarchaeological and lithic assemblages

The faunal assemblage from Layer L3 includes a total of 4817 remains (NR), out of which 133 have been classified taxonomically (Table 1):

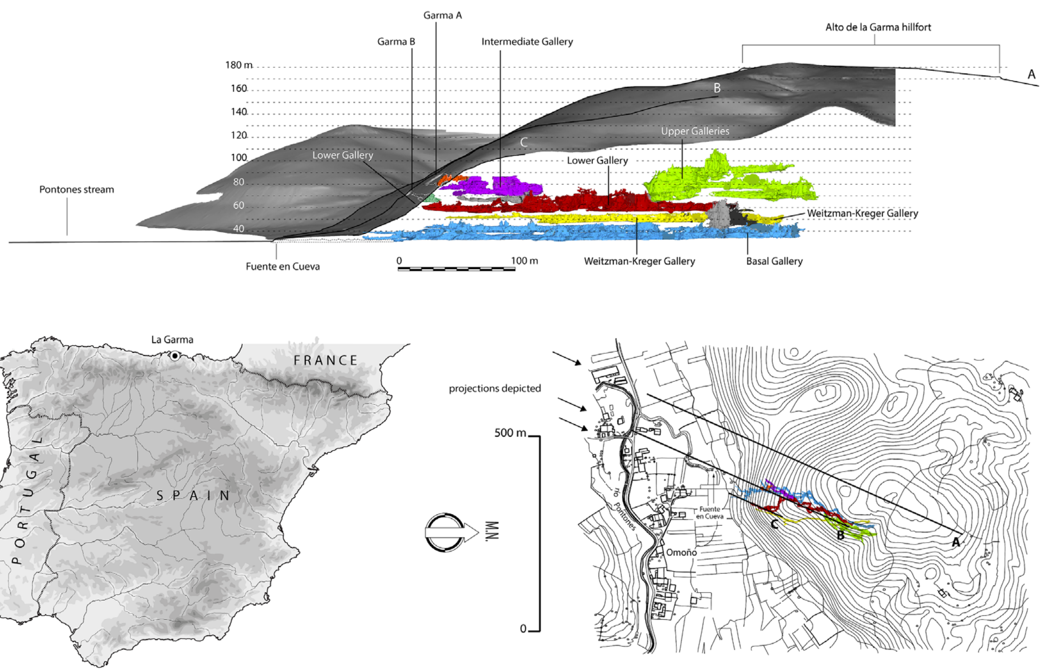

FIGURE 1 The location of La Garma Cave and the development of the karstic system. [Colour figure can be viewed at wileyonlinelibrary.com]

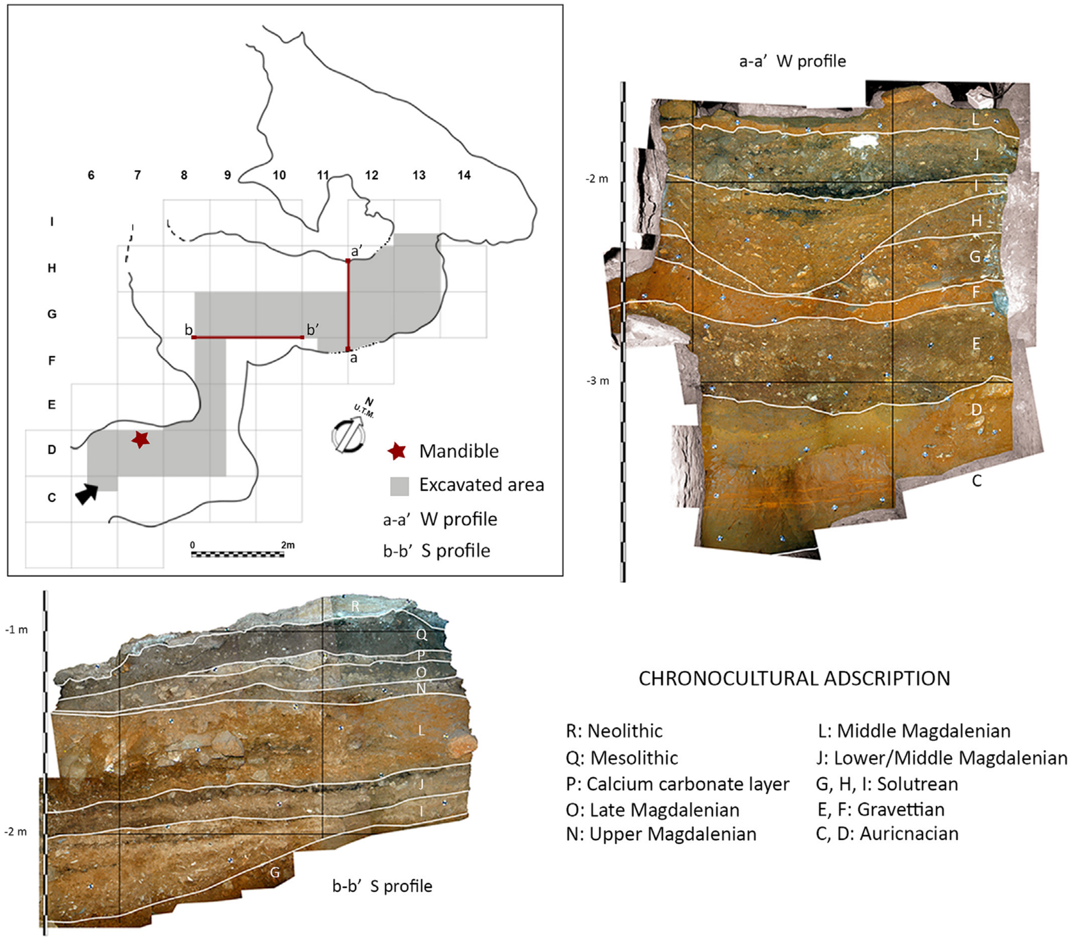

FIGURE 2 La Garma A planimetry with the location of the mandible and stratigraphic profiles and layers. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Number of remains (NR) and number of identified specimens (NISP) from layer L3 of La Garma A. The NR of indeterminate taxons is included. The percentage is calculated only for the NISP.

	NR	%
Bos	20	15.0
Equus caballus	63	47.4
Cervus elaphus	29	21.8
Rangifer tarandus	9	6.8
Capreolus capreolus	6	4.5
Capra pyrenaica	6	4.5
Total NISP	133	100
Indeterminate	4684	–
Total	4817	–

47% of horse (*E. caballus*), 22% of deer (*Cervus elaphus*), 15% of *Bos/Bison*, 7% of reindeer (*Rangifer tarandus*), and 4.5% each of ibex (*Capra pyrenaica*) and roe deer (*Capreolus capreolus*). The dominance of horse faunal remains is an exception within the Cantabrian Magdalenian, which has only been recorded in two of the sites of La Garma, La Garma A, and Zone IV at the Lower Gallery (Arias et al., 2011, 2005). The most common species represented in that period is red deer or ibex, depending on the orographic landscape surrounding the sites (see the faunal composition of different sites referred to in Yravedra Sáinz De Los Terreros, 2001 and Portero et al., 2024).

Concerning the lithic assemblage, the layer consists exclusively of tools knapped on flint, mainly blade technology (NR 25) (Figure S2): 20 backed bladelets, 2 triangles, 1 *microgravette* point, 1 broken backed bladelet, and 1 *dufour* bladelet. These objects constitute 27% of all the retouched tools (NR 93). Regarding the size, there are two well-differentiated groups: less than 6 mm wide and less than 12 mm wide. The retouched tool collection is completed with 20 burins (22%), 13 splintered pieces (14%), 7 continuous retouched pieces (7%), 5 truncated pieces (5%), followed by 6 notches and denticulates, 2 endscrapers, 1 borer-burin, 1 borer, 1 sidescraper, and 12 unclassified tools (Chauvin, 2012). Use-wear analysis links the lithic assemblage with activities related to skin/pelts and bone working processes (Arias et al., 2005).

2.3 | Methodology

A standardized archaeozoological analysis has been followed (Lyman, 1994; Reitz & Wing, 1999), consisting of an anatomical and taxonomical identification of the faunal remains using a referential osteological collection, sex determination, and age estimation following Guadeli (1998) and Sahara (2014). When possible, a taphonomical characterization has been conducted to identify both anthropic and non-anthropic modifications (e.g., postdepositional processes) following Fernandez-Jalvo and Andrews (2016). Such modifications were characterized macro- and microscopically, and specimens were imaged using a stereoscopic microscope Leica M80 (zoom range 0.75×–60×).

Beyond external surface modifications, internal bone structure characterization was conducted using a palaeoradiological approach, that is, X-ray and CT scan (model Y.CT Compact, 190 KV, 3.35 μm with a distance between slides of 0.20 mm in ventral cranial view and 0.30 mm in antero-posterior view).

The PIMs were characterized using existent archaeological experimental referential frameworks and the unified terminological and criteria defined by O'Driscoll and Thompson (2014) and Lewis (2008).

3 | RESULTS

The specimen analyzed here has been determined as a horse right hemimandible (Figure 3). Given the lower dentition, preserving from PM2 to M1, it can be stated that the equine individual was more than 5 years old. However, every tooth had its root damaged, making it difficult to precisely estimate the age by its measures (see Figure S3).

The species has been attributed to *E. caballus* given the measurements of the tooth occlusal surface, compared with available data for *E. caballus*, *Equus ferus*, and *Equus hydruntinus* (see Figure S4 and Table S2). Although we assume that there are no significant morphological differences between *E. caballus* and *E. ferus*, we follow Brugal et al. (2020), and we also use *E. caballus*.

The general stage of preservation is good; however, the mandibular corpus and the dentition are fragmented. In addition, the bone surface displays other postmortem modifications, such as a thin calcite formation covering most of the specimen (Figure 4a). Other non-anthropic modifications have been identified, including U-shaped non-linear marks identified as plant root damage (Figure 4b). Hydric

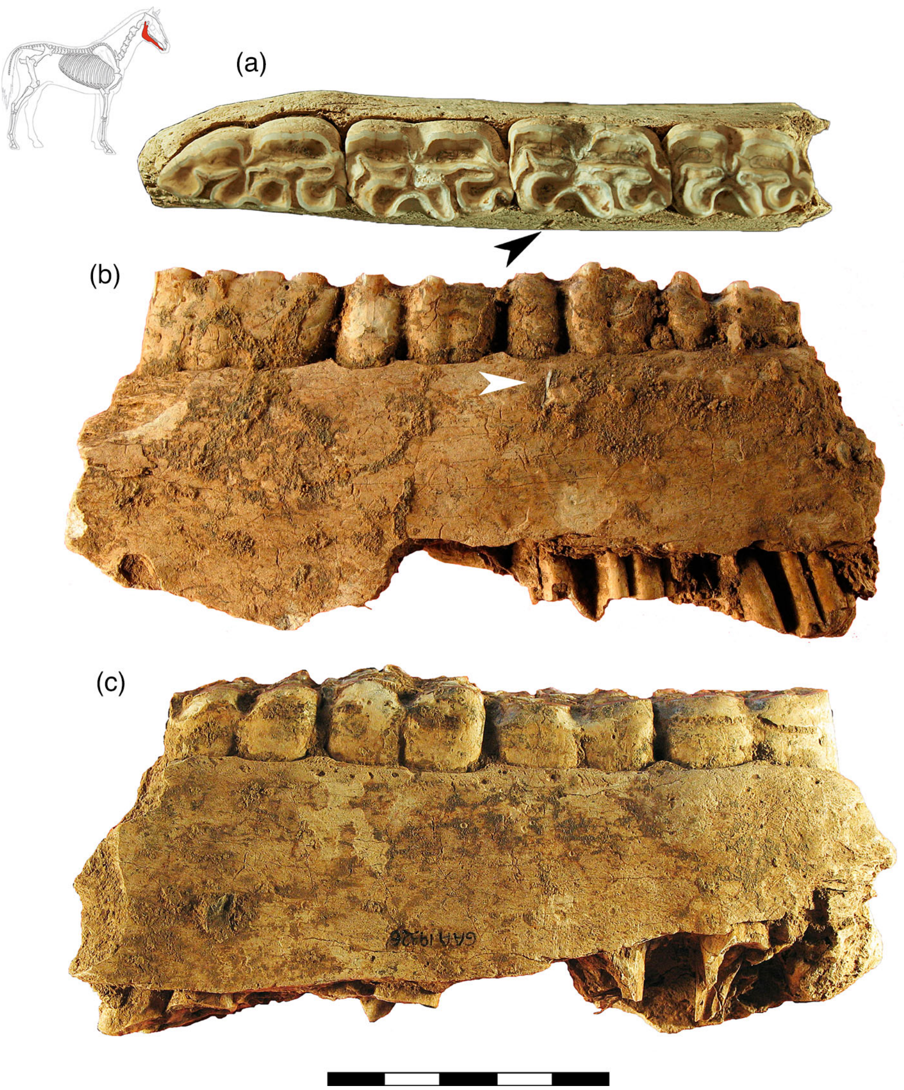

FIGURE 3 Horse hemimandible from layer L3 of La Garma: (a) occlusal surface; (b) lingual face with a lithic object embedded; and (c) buccal face with cut marks (see close-ups in Figure 4). [Colour figure can be viewed at wileyonlinelibrary.com]

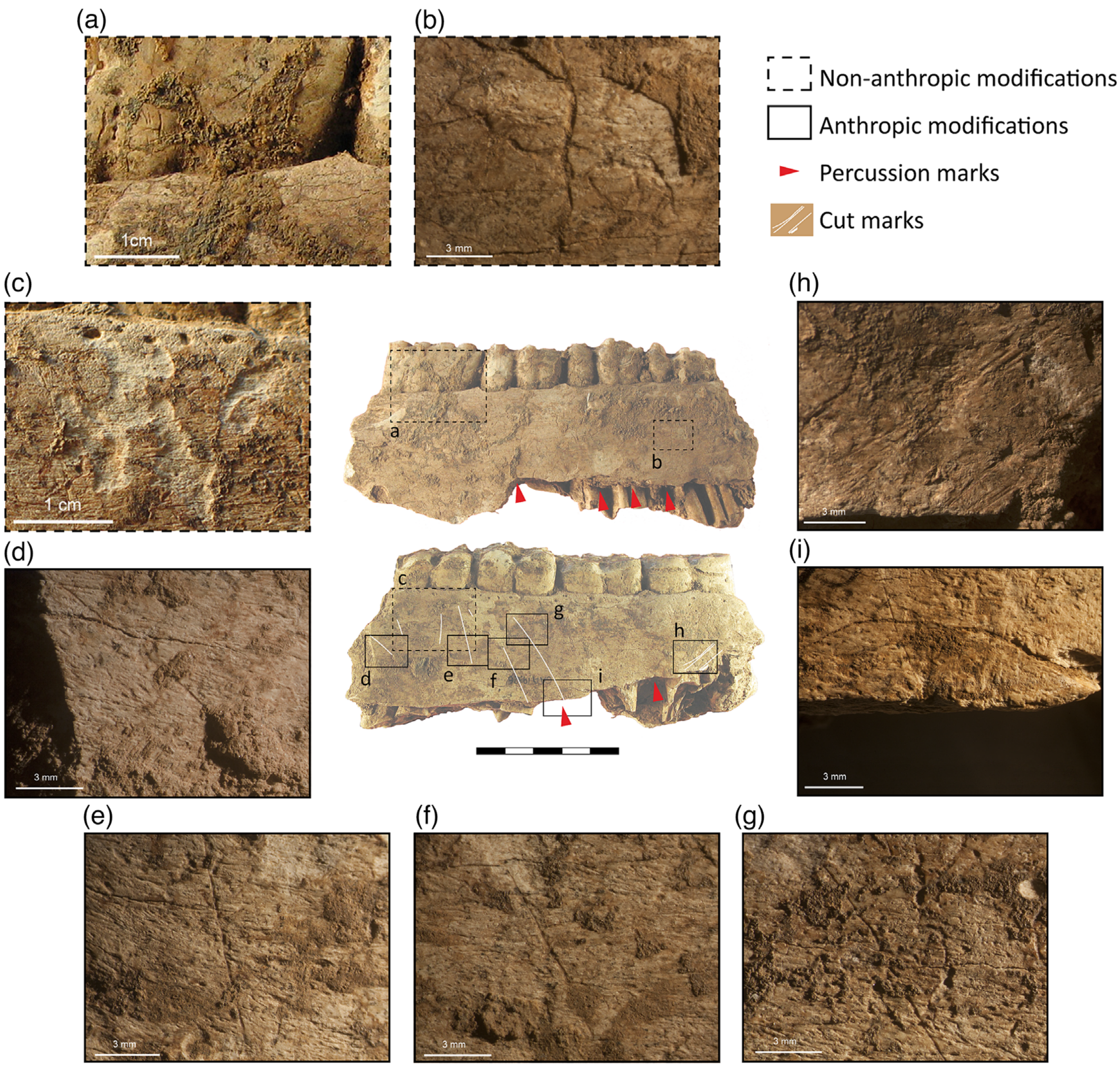

FIGURE 4 Anthropic and non-anthropic marks on the horse mandible: (a) calcite formation; (b) plant root; (c) hydric damage; (d–h) cut marks; (i) percussion and cut marks (see red arrows and white lines). [Colour figure can be viewed at wileyonlinelibrary.com]

damage, including calcareous concretion, had damaged the bone surface (Figure 4c).

Regarding the anthropic modifications, they have been made when the bone was in a fresh state condition and can be classified into three groups: cut marks, percussion marks, and PIMs. The cut marks are located on the buccal mandibular surface and grouped below P4 and M1 (Figure 4d–g). These cut marks are V-shaped and parallel. A second group of marks is located below P2 (Figure 4h). There are six percussion marks located on both anatomical sides of the mandible, buccal, and lingual (Figure 4). One of the percussion impacts is below the cut marks (Figure 4i), defining a clear sequence. The PIM is located on the lingual face of the mandible corpus, about 3 mm below P4, and preserving an embedded lithic artifact fragment (Figure 5a). This is associated with a drag-bisected mark in section and a flaked area on the right side (Figure 5b). According to the morphology of the drag (i.e., an increasing dragging surface towards the artifact) and the location of the lithic remains, a potential ventral-dorsal trajectory can be inferred (Figure 5c). The hertzian cones associated with the mark also support this idea. No bone remodeling (i.e., healing process) has been identified.

The lithic artifact is made of flint, although it is not possible to determine the specific variety of the raw material. The artifact is fragmented and measures 1.25 mm wide and 8.49 mm long on the visible surface. With the aim of characterizing the non-visible part of the artifact embedded in the internal bone structure, we implemented X-ray imaging and a CT scan (see Figures S3 and S5). However, results are not conclusive regarding the embedded morphology of the lithic artifact. Raw data is available in Data S1.

4 | DISCUSSION

The case described here focuses on an osteoarchaeological faunal remains consistent with a projectile lesion, also known as PIM. Our

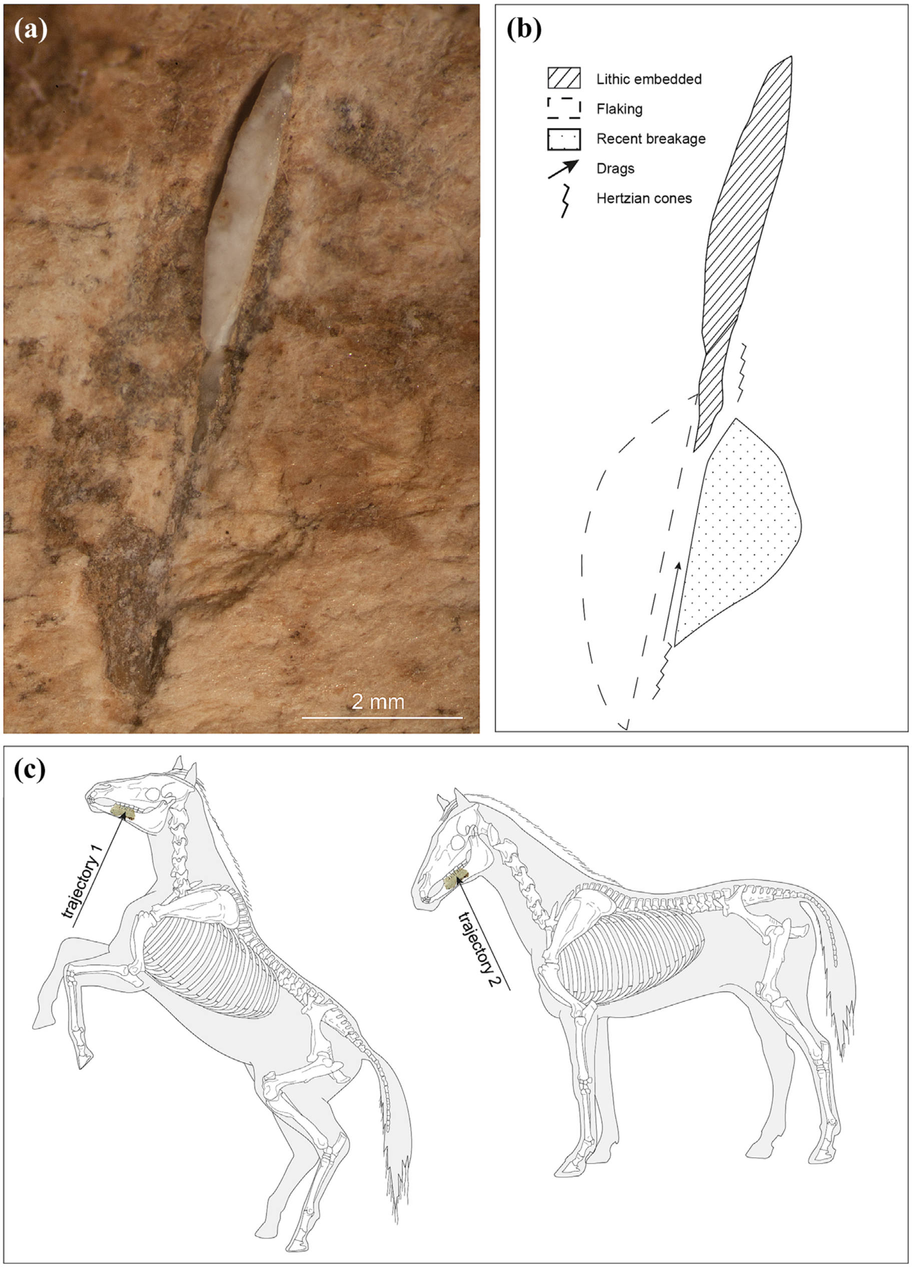

FIGURE 5 Projectile Impact Mark (PIM) and trajectory interpretation: (a) microscopical image of the PIM; (b) schematic representation of the PIM; and (c) potential trajectory of the projectile according to PIM features identified on the horse mandible. [Colour figure can be viewed at wileyonlinelibrary.com]

results point towards anthropic marks observed on the horse mandible that resemble diagnostic features in line with PIMs as described by O'Driscoll and Thompson (2014) and Crevecoeur et al. (2021), which can be differentiated from cut marks. Thus, our case displays dragging modifications that are wider and deeper than cut marks, including those observed in the case discussed here. In addition, flaking is commonly associated with projectile lesions at a higher frequency, according to actualistic experimentation, due to the high energy involved in the impact (O'Driscoll & Thompson, 2014). According to such experiments, only ~6% of the impacts displayed embedded lithic artifacts (*idem*: 403). Other experimental cases elevate the embedded PIM cases up to ~31% (Castel, 2008).

Therefore, our case is a singular one if interpreted as a PIM. Thus, we must first evaluate the timing of the anthropogenic modification. Given the absence of bone remodeling, we assume that it was generated near the time of death (i.e., perimortem). However, an alternative explanation (as in a differential diagnosis) included identifying the lithic fragment to have been attached to the bone surface in the context of faunal processing (e.g., butchering). But against this hypothesis, we object that no muscles or tendons are located on the internal surface of the mandible that justify such an impact during butchering activities. Actually, the butchering marks that we also identify in the present case are located on the buccal surface of the mandible, in line with the processing activities.

Therefore, assuming that the embedded lithic item was part of a fragmented projectile, it is a plausible explanation for the lesion described here that it was generated during hunting activities.

However, clear limitations can be raised concerning such interpretation given the uniqueness of our case, including the location of the artifact in the horse's anatomy. Firstly, an alternative explanation against the PIM interpretation could be adduced that Paleolithic hunters could have been shooting over dead prey for training purposes. However, following Bratlund (1991: 196), we assume that prehistoric hunters did not shoot over dead animals, and when an embedded projectile is located, this indicates hunting activities. Secondly, the location of the lithic artifact in our case study is unusual. When discussing hunting strategies, the location of the projectile itself or the remaining marks is essential, and targeting body areas are commonly associated with vital organs of the shoulder, such as the lungs and heart. As an example of this, at the site of Stellmoor (Germany), where a massive reindeer hunting event has been identified, the cranial region is not commonly linked to projectile lesions compared with ribs and vertebrae (*idem*), and they have been considered missed shots. Therefore, our case is not only on the head region but also on the lingual face, complicating the understanding of the potential trajectory. However, despite the limitations exposed, results point towards a consistent explanation: the discussed case here is an example of a hunting lesion from below with the head extremely raised, perhaps with the horse in a rampant position (see Figure 5c), including during their behavioral responses to predatory events (see Ahmadinejad et al., 2010 and references therein). This hypothesis is sustained by the fact that the projectile entrance angle is too close to consider a shot with the horse standing in a quadruped position. Both short and long shooting distances are possible.

Concerning the lithic remains, beyond the raw material identification, the X-ray and CT resulting images are not conclusive to identify the original technological morphology and the potential penetration depth. However, the transversal breakage is consistent with a high-speed fracture of an arrowhead impact on skin and bone, according to experimental macro-fracture pattern analysis (Ferdianto et al., 2022). If comparable with the mentioned experimental study, the lithic remains might have broken at the distal end of the point, preserving the embedded tip. This is also described in the archaeological experimental literature as a snap fracture (Fischer et al., 1984).

As discussed here, our study is consistent with a case evidencing a specific event of horse hunting using a high-speed projectile, potentially bow and arrow technology. Although this hunting technique has been observed in other Upper Paleolithic European sites for ungulates (e.g., Bratlund, 1991; Gaudzinski-Windheuser, 2016), this is, for the moment, a unique case in the Iberian Paleolithic. However, limitations in our interpretation are recognized, including its uniqueness in a lack of comparative cases and other plausible but less consistent scenarios from an embedded lithic artifact. Nonetheless, the study represents an advancement in the understanding of subsistence strategies through an interdisciplinary approach to osteoarchaeological remains with the aim of reconstructing past human behavior. Further analysis will require detailed bone surface observations, including some on less-commonly anthropic modified anatomical elements, with the aim of evidencing similar cases. Furthermore, future experimental referential studies are essential to bridge the gap between osteoarchaeological and lithic remains.

5 | CONCLUSIONS

An intensive taphonomic analysis of the bone surfaces of osteoarchaeological remains is key to approaching past human behavior. Here, we have discussed an Upper Paleolithic horse mandible from the Magdalenian period with an embedded lithic artifact suggesting a hunting lesion. The perimortem conditions of the modification (i.e., with no bone remodeling associated with a healing process), the marks allowing the reconstruction of a trajectory, the location among the animal's anatomy, and the characteristics of the lithic fragment all integrated, allow a regressive interpretation of the potential hunting strategy implemented to ambush the equid: from a lower position and with a high-speed weapon. Such observations are in line with previous archaeological Paleolithic European cases and experimental approaches, although it is unique evidence of an embedded lithic artifact from the Iberian Paleolithic. However, clear limitations are identified given the complexity of the analysis and the lack of referential and comparative cases among the archaeological record, in addition to equifinality concerning the presence of embedded lithic fragments. Nonetheless, the identification of such cases may represent direct evidence of a hunting strategy implemented and the use of specific technological development. Therefore, future osteoarchaeological analysis, both from human and faunal remains, requires a detailed taphonomic approach, including a microscopic bone surface analysis, in order to recover potential similar cases to advance in the reconstruction of past human behaviors.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data generated and analyzed during the present study are available on request from the corresponding author. The faunal remains studied are preserved in the Museo de Prehistoria y Arqueología de Cantabria—MUPAC (Santander).

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REFERENCES

Ahmadinejad, M., Hasani, A., & Kharaziyan, F. (2010). The responses of horses to predator stimuli. *Iranian Journal of Veterinary Medicine*, *4*, 5–9. https://doi.org/10.22059/ijvm.2010.20865

Arias, P., Ontañón Peredo, R., Álvarez Fernández, E., Aparicio, M. T., Chauvin, A., Clemente Conte, I., Cueto Rapado, M., González Urquijo, J. E., Ibáñez Estévez, J. J., Tapia Sagarna, J., & Teira Mayolini, L. C. (2005). *La estructura magdaleniense de La Garma A: aproximación a la organización espacial de un hábitat paleolítico, O Paleolítico: actas do IV Congresso de Arqueologia Peninsular (Faro, 14 a 19 de Setembro de 2004)*. Universidade do Algarve.

Arias, P., Ontañón, R., Álvarez-Fernández, E., Cueto, M., Elorza, M., & García-Moncó, C. (2011). Magdalenian floors in the Lower Gallery of La Garma. A preliminary approach. In S. Gaudzinski, O. Jöris, M. Sensburg, M. Street, & E. Turner (Eds.), *Site-internal spatial organization of Hunter-Gatherer Societies: Case studies from the European Palaeolithic and Mesolithic* (pp. 31–51). Verlag des Römisch-Germanischen Zentralmuseums.

Boëda, E., Geneste, J. M., Griggo, C., Mercier, N., Muhesen, S., Reyss, J. L., Taha, A., & Valladas, H. (1999). A Levallois point embedded in the vertebra of a wild ass (*Equus africanus*): Hafting, projectiles and Mousterian hunting weapons. *Antiquity*, *73*, 394–402. https://doi.org/10.1017/S0003598X00088335

Bratlund, B. (1991). A study of hunting lesions containing flint fragments on reindeer bones at Stellmoor, Schleswig-Holstein, Germany. In N. Barton, A. J. Roberts, & D. A. Roe (Eds.), *The late glacial in North-West Europe: Human adaptation and environmental change at the end of the Pleistocene* (pp. 193–207). Council for British Archaeology.

Bronk Ramsey, C., 2021. OxCal v. 4.4. 4 [software].

Brugal, J.-P., Argant, A., Boudadi-Maligne, M., Crégut-Bonnoure, E., Croitor, R., Fernandez, P., Fourvel, J.-B., Fosse, P., Guadelli, J.-L., Labe, B., Magniez, P., & Uzunidis, A. (2020). Pleistocene herbivores and carnivores from France: An updated overview of the literature, sites and taxonomy. *Annales de Paléontologie*, *106*, 102384. https://doi.org/10.1016/j.annpal.2019.102384

Castel, J.-C. (2008). Identification des impacts de projectiles sur le squelette des grands ongulés. *Annales de Paléontologie*, *94*, 103–118. https://doi.org/10.1016/j.annpal.2008.03.003

Chauvin, A., 2012. Tecnología lítica de los cazadores-recolectores del final del Pleistoceno. La producción y transformación de los soportes en La Garma A (Cantabria, España) entre ca. 15000 y 12000 cal BC. BAR International Series, 2336, Oxford.

Crevecoeur, I., Dias-Meirinho, M. H., Zazzo, A., Antoine, D., & Bon, F. (2021). New insights on interpersonal violence in the Late Pleistocene based on the Nile valley cemetery of Jebel Sahaba. *Scientific Reports*, *11*, 9991. https://doi.org/10.1038/s41598-021-89386-y

Duches, R., Nannini, N., Fontana, A., Boschin, F., Crezzini, J., Bernardini, F., Tuniz, C., & Dalmeri, G. (2019). Archeological bone injuries by lithic backed projectiles: New evidence on bear hunting from the Late Epigravettian site of Cornafessa rock shelter (Italy). *Archaeological and Anthropological Sciences*, *11*, 2249–2270. https://doi.org/10.1007/s12520-018-0674-y

Duches, R., Nannini, N., Fontana, A., Boschin, F., Crezzini, J., & Peresani, M. (2020). Experimental and archaeological data for the identification of projectile impact marks on small-sized mammals. *Scientific Reports*, *10*, 9092. https://doi.org/10.1038/s41598-020-66044-3

Duches, R., Nannini, N., Romandini, M., Boschin, F., Crezzini, J., & Peresani, M. (2016). Identification of Late Epigravettian hunting injuries: Descriptive and 3D analysis of experimental projectile impact marks on bone. *Journal of Archaeological Science*, *66*, 88–102. https://doi.org/10.1016/j.jas.2016.01.005

Ferdianto, A., Fakhri, S., Hakim, B., Sutikna, T., & Lin, S. C. (2022). The effect of edge serration on the performance of stone-tip projectiles: An experimental case study of the Maros Point from Holocene South Sulawesi. *Archaeological and Anthropological Sciences*, *14*, 152. https://doi.org/10.1007/s12520-022-01620-4

Fernández-Crespo, T., Ordoño, J., Etxeberria, F., Herrasti, L., Armendariz, Á., Vegas, J. I., & Schulting, R. J. (2023). Large-scale violence in Late Neolithic Western Europe based on expanded skeletal evidence from San Juan ante Portam Latinam. *Scientific Reports*, *13*, 1–17. https://doi.org/10.1038/s41598-023-43026-9

Fernandez-Jalvo, Y., & Andrews, P. (2016). Atlas of taphonomic identifications. In *Vertebrate paleobiology and paleoanthropology*. Springer Netherlands. https://doi.org/10.1007/978-94-017-7432-1

Fischer, A., Hansen, P. V., & Rasmussen, P. (1984). Macro and micro wear traces on lithic projectile points. *Journal of Danish Archaeology*, *3*, 19–46. https://doi.org/10.1080/0108464X.1984.10589910

Gaudzinski-Windheuser, S. (2016). Hunting lesions in Pleistocene and Early Holocene European bone assemblages and their implications for our knowledge on the use and timing of lithic projectile technology. In R. Iovita & K. Sano (Eds.), *Multidisciplinary approaches to the study of stone age weaponry. Vertebrate Paleobiology and paleoanthropology* (pp. 77–100). Springer. https://doi.org/10.1007/978-94-017-7602-8_6

Gaudzinski-Windheuser, S., Noack, E. S., Pop, E., Herbst, C., Pfleging, J., Buchli, J., Jacob, A., Enzmann, F., Kindler, L., Iovita, R., Street, M., & Roebroeks, W. (2018). Evidence for close-range hunting by last interglacial Neanderthals. *Nature Ecology & Evolution*, *2*, 1087–1092. https://doi.org/10.1038/s41559-018-0596-1

Guadeli, J.-L. (1998). Détermination de l'age des chevaux fossiles et établissement des classes d'age. *Paléo*, *10*, 87–93. https://doi.org/10.3406/pal.1998.1130

Leduc, C. (2014). New Mesolithic hunting evidence from bone injuries at Danish Maglemosian sites: Lundby Mose and Mullerup (Sjælland). *International Journal of Osteoarchaeology*, *24*, 476–491. https://doi.org/10.1002/oa.2234

Letourneux, C., & Pétillon, J. M. (2008). Hunting lesions caused by osseous projectile points: Experimental results and archaeological implications. *Journal of Archaeological Science*, *35*, 2849–2862. https://doi.org/10.1016/j.jas.2008.05.014

Lewis, J. E. (2008). Identifying sword marks on bone: Criteria for distinguishing between cut marks made by different classes of bladed weapons. *Journal of Archaeological Science*, *35*, 2001–2008. https://doi.org/10.1016/j.jas.2008.01.016

Lyman, R. L. (1994). *Vertebrate taphonomy*. Cambridge University Press. https://doi.org/10.1017/CBO9781139878302

Marginedas, F., Vergès, J. M., Saladié, P., & Rodríguez-Hidalgo, A. (2024). Examining cut mark residue with SEM to identify metal tool use: An experimental study. *Micron*, *180*, 103614. https://doi.org/10.1016/j.micron.2024.103614

Milo, R. G. (1998). Evidence for hominid predation at Klasies River Mouth, South Africa, and its implications for the behaviour of early modern humans. *Journal of Archaeological Science*, *25*, 99–133. https://doi.org/10.1006/jasc.1997.0233

Mirazón Lahr, M., Rivera, F., Power, R. K., Mounier, A., Copsey, B., Crivellaro, F., Edung, J. E., MáilloFernández, J. M., Kiarie, C., Lawrence, J., Leakey, A., Mbua, E., Miller, H., Muigai, A., Mukhongo, D. M., Van Baelen, A., Wood, R., Schwenninger, J. L., Grün, R., … Foley, R. A. (2016). Inter-group violence among early Holocene hunter-gatherers of West Turkana, Kenya. *Nature*, *529*, 394–398. https://doi.org/10.1038/nature16477

Morel, P. (1999). Une chasse à l'ours brun il y a 12′000 ans: nouvelle découverte à la grotte du Bichon (La Chaux-de-Fonds). *Archäologie der Schweiz/Archéologie suisse*, *16*, 110–117. https://doi.org/10.5169/seals-14110

Münzel, S. C., & Conard, N. J. (2004). Cave bear hunting in the Hohle Fels, a cave site in the AchValley, Swabian Jura. *Revue de Paléobiologie*, *23*, 877–885.

Nikolskiy, P., & Pitulko, V. (2013). Evidence from the Yana Palaeolithic site, Arctic Siberia, yields clues to the riddle of mammoth hunting. *Journal of Archaeological Science*, *40*, 4189–4197. https://doi.org/10.1016/j.jas.2013.05.020

O'Driscoll, C. A., & Thompson, J. C. (2014). Experimental projectile impact marks on bone: Implications for identifying the origins of projectile technology. *Journal of Archaeological Science*, *49*, 398–413. https://doi.org/10.1016/j.jas.2014.05.036

Portero, R., Fernández-Gómez, M. J., & Álvarez-Fernández, E. (2024). Revisiting macromammal exploitation in the Spanish Cantabrian region during the lower Magdalenian (ca. 20-17 ky cal BP). *Quaternary Science Reviews*, *332*, 108651. https://doi.org/10.1016/j.quascirev.2024.108651

Reimer, P. J., Austin, W. E. N., Bard, E., Bayliss, A., Blackwell, P. G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kromer, B., Manning, S. W., Muscheler, R., … Talamo, S. (2020). The IntCal20 northern hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon*, *62*, 725–757. https://doi.org/10.1017/RDC.2020.41

Reitz, E. J., & Wing, E. S. (1999). *Zooarchaeology*. Cambridge University Press.

Sahara, N. (2014). Development of coronal cementum in hypsodont horse cheek teeth. *The Anatomical Record*, *297*, 716–730. https://doi.org/10.1002/ar.22880

Smith, G. M., Noack, E. S., Behrens, N. M., Ruebens, K., Street, M., Iovita, R., & Gaudzinski-Windheuser, S. (2020). When lithics hit bones: Evaluating the potential of a multifaceted experimental protocol to illuminate Middle Palaeolithic weapon technology. *Journal of Paleolithic Archaeology*, *3*, 126–156. https://doi.org/10.1007/s41982-020-00053-6

Wojtal, P., Haynes, G., Klimowicz, J., Sobczyk, K., Tarasiuk, J., Wroński, S., & Wilczyński, J. (2019). The earliest direct evidence of mammoth hunting in Central Europe—The Kraków Spadzista site (Poland). *Quaternary Science Reviews*, *213*, 162–166. https://doi.org/10.1016/j.quascirev.2019.04.004

Yravedra Sáinz De Los Terreros, J. (2001). Zooarqueología de la Península Ibérica. In *Implicaciones Tafonómicas y Paleoecológicas en el debate de los homínidos del Pleistoceno Superior, BAR Intern. ed*. Archaeopress, Oxford. https://doi.org/10.30861/9781841711881

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