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Death in the high mountains: Evidence of interpersonal violence during Late Chalcolithic and Early Bronze Age at Roc de les Orenetes (Eastern Pyrenees, Spain)

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Abstract

Objectives: To test a hypothesis on interpersonal violence events during the transition between Chalcolithic and Bronze Age in the Eastern Pyrenees, to contextualize it in Western Europe during that period, and to assess if these marks can be differentiated from secondary funerary treatment.

Materials and Methods: Metric and non-metric methods were used to estimate the age-at-death and sex of the skeletal remains. Perimortem injuries were observed and analyzed with stereomicroscopy and confocal microscopy.

Results: Among the minimum of 51 individuals documented, at least six people showed evidence of perimortem trauma. All age groups and both sexes are represented in the skeletal sample, but those with violent injuries are predominantly males. Twenty-six bones had 49 injuries, 48 of which involved sharp force trauma on post-cranial elements, and one example of blunt force trauma on a cranium. The wounds were mostly located on the upper extremities and ribs, anterior and posterior. Several antemortem lesions were also documented in the assemblage.

Discussion: The perimortem lesions, together with direct dating, suggest that more than one episode of interpersonal violence took place between the Late Chalcolithic and the Early Bronze Age in northeastern Spain. The features of the sharp force trauma indicate that different weapons were used, including sharp metal objects and lithic projectiles. The Roc de les Orenetes assemblage represents a scenario of recurrent lethal confrontation in a high mountain geographic context, representing the evidence of inferred interpersonal violence located at the highest altitude settings in the Pyrenees, at 1836 meters above sea level.

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Resumen

Objetivos: Estudiar nuevas evidencias de violencia interpersonal durante la transición entre el Calcolítico y la Edad del Bronce en los Pirineos Orientales, contextualizarlas en la Europa occidental durante ese periodo, y diferenciar estas marcas del tratamiento funerario secundario.

Materiales y Métodos: Se han utilizado métodos métricos y no métricos para estimar la edad de muerte y sexo de los restos esqueléticos. Las heridas perimortem fueron observadas y analizadas con estereomicroscopio y microscopio confocal.

Resultados: Entre el mínimo de 51 individuos documentados en el yacimiento, al menos seis individuos mostraron evidencias de traumas perimortem. Todos los grupos de edad y ambos sexos están representados en el enterramiento, pero aquellos con heridas violentas son mayoritariamente masculinos. Veintiséis huesos tenían un total de 49 lesiones, 48 de ellos traumatismos cortantes en elementos postcraneales, y un traumatismo contundente en un cráneo. Las heridas estaban mayoritariamente localizadas en las extremidades superiores y costillas, tanto anterior como posterior. Varias lesiones antemortem fueron también documentadas en el conjunto.

Discusión: Las lesiones perimortem, junto a las dataciones directas, sugieren que se produjo más de un episodio de violencia interpersonal entre el Calcolítico Final y la Edad del Bronce Antiguo en el noreste de España. Las características de los traumatismos cortantes indican que se utilizaron diferentes armas, incluyendo objetos cortantes de metal y proyectiles líticos. El conjunto de Roc de les Orenetes representa un escenario de confrontaciones letales recurrentes en un contexto geográfico de alta montaña, representando la evidencia de violencia interpersonal localizada a mayor altitud de los Pirineos, a 1836 metros sobre el nivel del mar.

KEYWORDS

perimortem trauma, Pyrenees, paleopathology, lithic projectile, metal weapons

1 | INTRODUCTION

Violence has been part of human behavior since the Paleolithic (Churchill et al., 2009; Knüsel et al., 2023; Sala et al., 2015; Zollikofer et al., 2002), but from the Neolithic period onwards an important change is observed in Europe involving a general increase in violent behavior (Guilaine & Zammit, 2005; Schulting & Fibiger, 2012; Smith, 2017). This is associated with the large number of social, economic, demographic, technological, and cultural changes that occurred at the beginning of this period (Larsen, 2006; Whittle, 1996), and is also partly a function of increasingly better preservation of human remains as a result of more ritualized funerary practices, especially collective burials.

Since the Neolithic and continuing into the Chalcolithic and Bronze Age, there are numerous cases of inter-group confrontations in the archeological record (Alt et al., 2020; Brinker et al., 2016; Golitko & Keeley, 2007; Janković et al., 2021; Jiménez-Brobeil et al., 2009; Konopka et al., 2016; Meyer et al., 2015). The remains of the victims were buried in both open-air mass graves and placed in monumental structures or caves as part of successive collective burials. The latter is the case at Roc de les Orenetes (Queralbs, Girona), a cave where the skeletal remains of multiple individuals have been found, with some of their bones displaying perimortem blunt and, especially, sharp force trauma. The first step to be taken involves identification of this type of injury as being caused by violent confrontations.

Human funerary practices are part of the symbolic sphere and beliefs of societies, which is why they are highly diverse and complex. It is possible to find funerary practices that include the manipulation of human remains either before or after burial (Belcastro et al., 2021; Crozier, 2016; Duday, 2009; Erdal, 2015; Fowler, 2010; Geber et al., 2017; Mariotti et al., 2020; Robb et al., 2015; Santana et al., 2012, 2015; Simmons et al., 2007; Wallduck & Bello, 2016). The processing of the bodies for consumption in episodes of cannibalism is another scenario in which blows and cut marks on the bones are documented (Andrews & Fernández-Jalvo, 2003; Bello et al., 2015, 2016; Boulestin & Coupey, 2015; Cáceres et al., 2007; Marginedas et al., 2022; Nicolosi et al., 2023; Rougier et al., 2016; Sala &

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Conard, 2016; Saladié et al., 2012; Saladié & Rodríguez-Hidalgo, 2017; Santana et al., 2019; Turner & Turner, 1999; White, 1992). Identifying the etiology of perimortem injuries as a result of a specific practice can radically change the interpretation of a given burial. For this reason, one of the main objectives of the present work is to carry out an in-depth description and analysis of the perimortem injuries documented at the Roc de les Orenetes site. We discuss here why their morphological features and location on the skeleton are consistent with an episode of interpersonal violence but not with food processing or funerary practices.

Evidence of violence in skeletal remains, such as antemortem and perimortem wounds, often related to the manner of death of individuals. This informs us about the hazards of living in prehistoric communities. We should not think that Europe between the Neolithic and Bronze Age was immersed in a constant atmosphere of violence, but rather, sporadic confrontations were generally on a small or medium scale. Aims of such violence rarely sought to annihilate an opposing group, and the majority involved non-lethal skirmishes over social, resource-based, or territorial disputes (Fibiger et al., 2023; Golitko & Keeley, 2007; Larsen, 2006; Schulting & Fibiger, 2012; Schulting & Wysocki, 2005; Smith, 2017; Soriano et al., 2015; Wild et al., 2004).

Signs of violence on the skeleton not only inform us about past confrontations, but also illuminate about the circumstances surrounding the death of individuals, such as the type of weapons used, the direction of the attacks, and the demographic profile of the victims. This can provide information on whether it was an intergroup fight or a one-way massacre. It makes it possible to discern whether we are dealing with the victims of an assault or execution, or with those killed in interpersonal or intergroup confrontations. The transition between the Late Chalcolithic and the Early Bronze Age in Western Europe involved a broad spectrum of social, economic and technological transformations, and the inevitable disputes that these large-scale reformulations brought with them (Blanco-González et al., 2018; Brinker et al., 2016; Guilaine & Zammit, 2005; Harding, 2007; Janković et al., 2021; Smith, 2017; Soriano, 2013). Here, a taphonomic analysis of the marks of violence documented at the Roc de les Orenetes site provides a detailed reconstruction and interpretation of the circumstances surrounding the deaths of these individuals. This study, together with the first direct dating carried out on the buried individuals, provides a chronological and geographical contextualization of this collective burial, located in the high mountains of the Eastern Pyrenees.

2 | THE SITE OF ROC DE LES ORENETES

Roc de les Orenetes is a karstic cave located in the Eastern Pyrenees in the municipality of Queralbs (Girona, Spain), at an altitude of 1836 m above sea level (Figure 1). The cave consists of a main gallery 17 m long, 1–4 m wide, and an average height of 1.5 m. The entrance is a small and narrow mouth oriented southwest, which provides access directly to this chamber. A secondary and smaller access point to the cave is possible through an inferior gallery, located two meters below, although it is today inaccessible.

The site was discovered by a local resident in 1969, and in 1972–1973 two archeological rescue projects were carried out. As a result of this fieldwork, more than a thousand human bones were recovered, along with faunal remains, ceramic fragments, and bronze ornamental objects (Carbonell et al., 1985; Soriano, 2013; Toledo, 1990; Toledo & Pons, 1982). It was confirmed that the cave was used as a collective burial chamber, and it was chrono-culturally consistent with the Bronze Age by the metallic elements found. No further investigations were carried out in the cave until its reopening in 2019 as part of a new research project (CLT009/18/00048) (Ramírez-Pedraza et al., 2020), which continues today (CLT009/22/000042) (Ramírez-Pedraza et al., 2022). New fieldwork began in 2019 with a 2×1 m test pit, which has been expanded with each excavation in successive years. The cave has not yet been completely excavated.

At the moment, a single archeological layer has been documented, forming the upper 20 cm of the vertical stratigraphic profile. Below it, a sterile layer follows, clearly differentiated from the archeological one in both texture and sedimentary composition, and the natural base of the cave has not yet been found. No stratigraphic differentiation is observed within the archeological layer, which presents a high density of mainly highly commingled human bones (Supporting Information, Figure S1). The total recovery of skeletal remains was ensured by water-sieving all sediment that came from this layer. The archeological remains found suggest that the cave was mainly used for funerary purposes and no other activities have been documented at the site to date.

In the most recent excavations, some faunal remains, ceramic fragments, small charcoal concretations and five tanged and barbed projectile points have been recovered at the site. The projectiles were found both on surface and in stratigraphic context. Four of them are made of chert and one of bone.

The first set of ^{14}C dates from the site was carried out on six human bones bearing anthropogenic marks of violence (Table 1, Figure 2), involving of one cranium, four humeri, and two radii. These samples came from both the 1972 to 1973 excavations and the 2019–2021 field seasons. The processing of the dates with Bayesian modeling made it possible to establish that the episodes of interpersonal violence occurred over 400 years, from 4500 to 4100 years cal. BP (Figure 2) (2550–2150 cal. BC). These dates are culturally framed between the Late Chalcolithic and the Early Bronze Age, which in the northeast of the Iberian Peninsula (today, Catalonia) spans *c*. 4700–4250 and *c*. 4250–3750 years cal. BP (Clop & Majó, 2017; Oms et al., 2016; Soriano, 2013, 2016). However, the bronze ornaments indicate a funerary use of the cave into the Bronze Age (Soriano, 2013). This successive use of the caves as a funerary space over a long period is very frequent in collective burials from the Neolithic onwards (Aranda Jiménez et al., 2020; Bosch et al., 2016; Lorrio & Montero, 2004; Moreno-Ibáñez et al., 2022).

3 | MATERIALS AND METHODS

All human remains analyzed for this study from the Roc de les Orenetes site are part of both the 2019, 2020, and 2021 field seasons as

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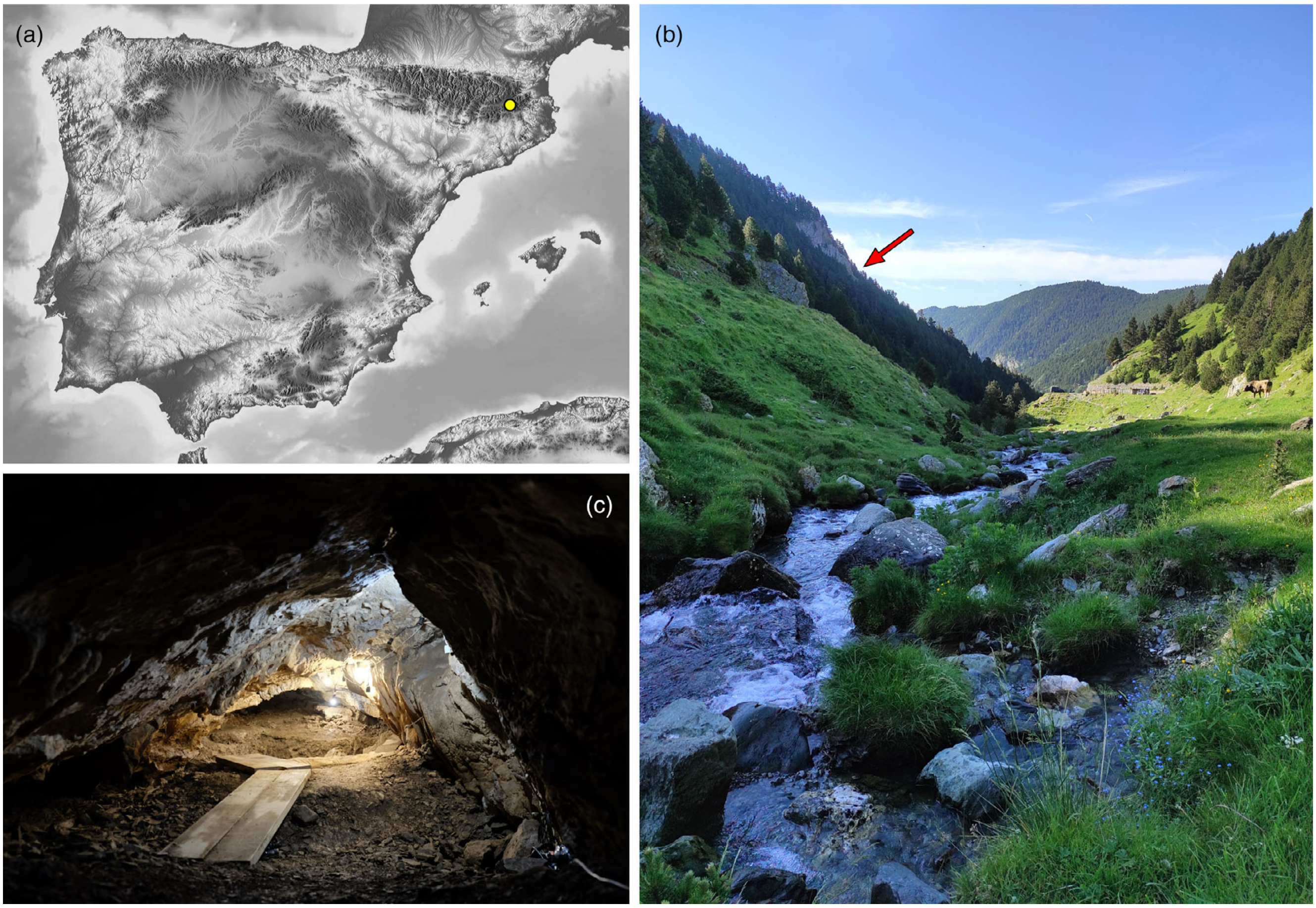

FIGURE 1 (a) Location of the Roc de les Orenetes site on the Iberian Peninsula; (b) view of the cave location (rocky area on the red arrow) from the Tosa River, near the Font de l'Home Mort; and (c) interior of the cave seen from the entrance).

TABLE 1 Radiocarbon dates from Roc de les Orenetes.

Sample	Label	Technique	Reference	BP age	Cal. BP 95%	Cal. BC 95%
Radius	Ro20-2126	AMS	D-AMS 049462	4013 ± 34	4572–4414	2623–2465
Humerus	Ro20-1902	AMS	D-AMS 049461	3979 ± 33	4527–4300	2578–2351
Cranium	Ro73-5986	AMS	D-AMS 051650	3963 ± 26	4521–4298	2572–2349
Humerus	Ro73-4711.1	AMS	D-AMS 049458	3958 ± 30	4520–4295	2571–2346
Humerus	Ro73-6363	AMS	D-AMS 049459	3912 ± 29	4420–4246	2471–2297
Humerus	Ro73-6325	AMS	D-AMS 049460	3876 ± 30	4414–4158	2465–2209
Radius	Ro21-3453	AMS	Beta – 615,082	3780 ± 30	4246–4081	2297–2132

part of the ARRELS project ("Arrels prehistòriques de la transhumància a l'Alt Ripollès"), and from the rescue excavation that took part in 1972–1973. A total of 3993 identifiable skeletal remains has been analyzed: 1084 from the 1970s excavations, and 2909 from the 2019–2021 excavations. Although most of the material has already been recovered, the excavation of the cave is not yet finished, and more human remains are expected to be retrieved in the coming years. All bones were found completely disarticulated, commingled, and partially fragmented. No anatomical connections were observed during the excavation.

Osteological study of the bones was carried out at the Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA, Tarragona, Spain). Due to the disarticulated, commingled, and partially fragmented state of the remains, different quantification indices were taken into account: the number of identified specimens (NISP), minimum number of elements (MNE), and minimum number of individuals (MNI) (Grayson, 1984; Klein & Cruz-Uribe, 1984). Skeletal elements were identified following criteria in manuals on human osteology and physical anthropology (France, 2009; Schaefer et al., 2009; White et al., 2011), as well as using the IPHES reference collection. The

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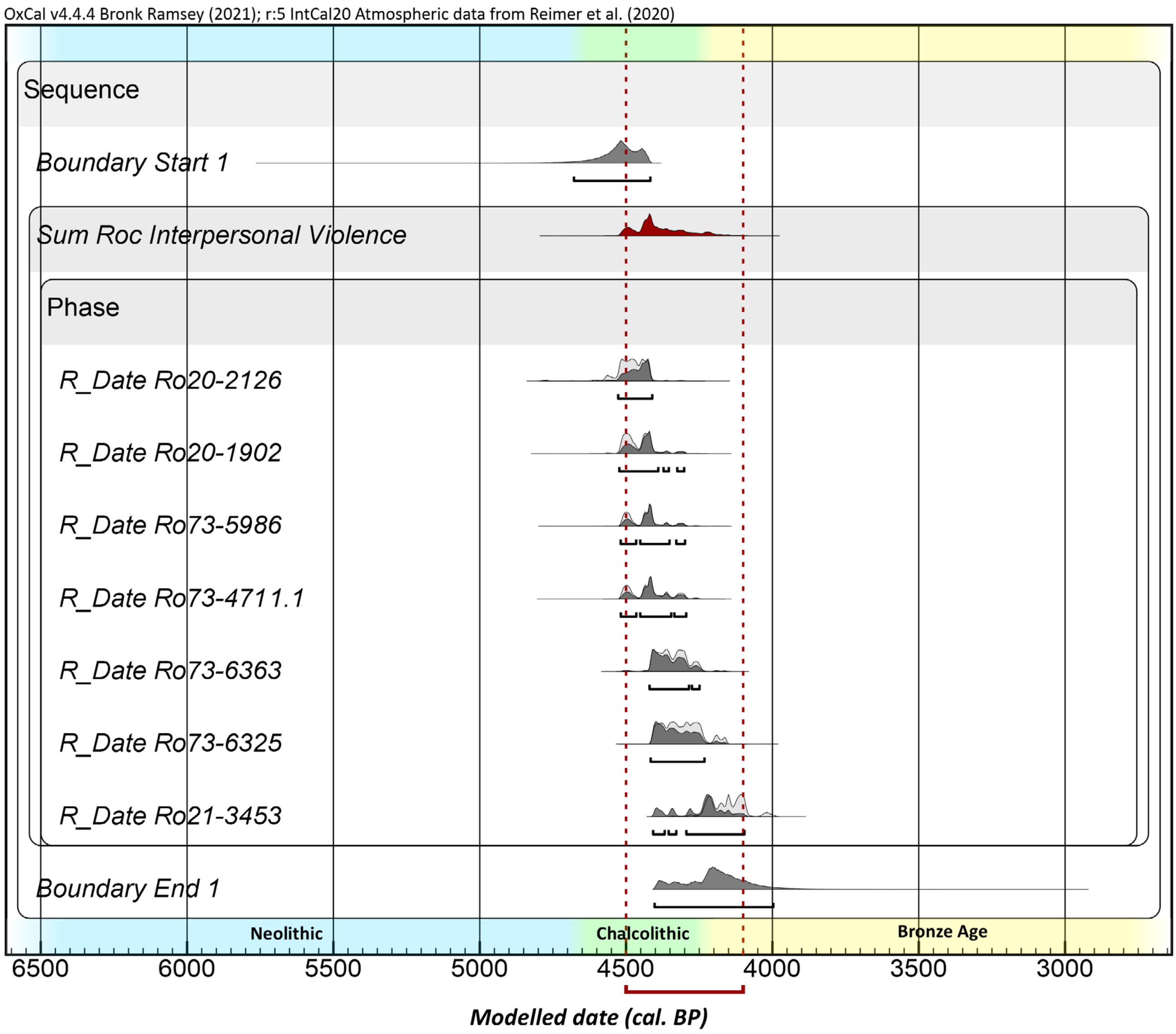

FIGURE 2 Calibration and modeling of the ^{14}C dates from Roc de les Orenetes through OxCal 4.4. software (Ramsey, 2009; Reimer et al., 2020), including the "Sum" function (in red) (Ramsey, 2017), to visualize the chronological range in which the dates are framed.

MNE was calculated by the overlapping of bone areas in the case of fragmented remains. The MNI was calculated by the maximum repetition of the left tibia, and dental remains, of which the lower left M2 provided the highest number of adult individuals. The horizontal plot of the bones recovered during the excavation was made to better visualize the excavated area. The estimation of the age-at-death and sex of the skeletal remains was performed following different standard metric and non-metric bioarcheological methods and are described in the Supporting Information (SI).

Both antemortem and perimortem traumatic injuries were identified, described, and discussed, following forensic criteria on fracture patterns and other signs of violence (Kimmerle & Baraybar, 2008; Lovell, 1997; Symes et al., 2012; Wedel & Galloway, 2014). Among the documented perimortem lesions, blunt force trauma (BFT) and sharp force trauma (SFT) are differentiated. BFT is characterized by a blow from an object or surface at low velocity (i.e., an object held in an aggressor's hand) with a relatively broad impact surface. SFT is characterized by the application of compressive or shearing forces with a sharp cutting edge over a narrow area of impact (Kimmerle & Baraybar, 2008; Lovell, 1997; Symes et al., 2002, 2012; Wedel & Galloway, 2014). In the case of the ulna Ro73-7291 with an antemortem fracture, a radiograph was obtained at the Sant Pau i Santa Tecla Hospital in Tarragona, using a Siemens Fluorospot Compact FD equipment, with an energy of 47.9 kV and 2.02 mAs.

Within the occurrences of sharp force (or cut mark) trauma, we differentiated between chop marks and slice marks. The former represents forceful SFT that penetrates cortical bone to a greater depth caused by the perpendicular impact of an edged object (Downing & Fibiger, 2017; Lewis, 2008; Lynn & Fairgrieve, 2009; Mariotti et al., 2020; Okaluk & Greenfield, 2022; Tumler et al., 2019). Slice

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marks are superficial defects caused by a sharp cutting edge with a sliding movement across the surface of the bone (Bello et al., 2016; Courtenay et al., 2019; Crowder et al., 2013; de Juana et al., 2010; Domínguez-Rodrigo et al., 2009; Greenfield, 2006; Pérez, 2012). Long slice marks, following the longitudinal axis of the bone, and slightly wider and shallower, are called scrape marks.

These lesions were observed using an OPTECH HZ stereomicroscope, with 15–45× magnification. When necessary, for better documentation, we used the 3D digital microscope HIROX KH-8700, and a Sensofar S-Neox 3D Optical Profiler (SSN09000) confocal microscope in the microscopy laboratory of IPHES. These microscopes generate a 3D reconstruction of the cut marks, permitting precise measurements, detailed visualization of the cross-sections, walls, and bottom of the chop and slice marks. Images obtained with confocal microscopy, as well as the raw 3D scans, can be found in the Supporting Information. The characterization of all these features was used for the accurate identification of the incisions as cut marks.

A use-wear analysis was carried out on all arrowheads recovered from the site (four made of chert and one made of bone), following our own multimethod and multiscalar analysis system for projectiles (Fernández-Marchena et al., 2020). This approach is based directly on the combined methods of diagnostic impact fracture analysis developed by Fischer et al. (1984) and the analysis of microscopic linear impact traces (MLIT) by Moss (1983). In this case, we had to re-adjust part of the sample processing protocol to adapt to the characteristics of some of the materials analyzed, such as bone points or chert arrowheads with poor preservation (Mateo-Lomba et al., 2022). In addition, a comparative functional bibliography was consulted on this type of artifact, which has not often been done from a functional perspective (Gibaja et al., 2006; Gibaja & Palomo, 2003; Palomo, 2002; Sosna, 2012). The analysis was carried out in IPHES's microscopy laboratory, using an OPTECH HZ stereomicroscope, HIROX KH-8700 3D digital microscope, Zeiss Axio Scope A1 metallographic microscope, and Sensofar S-Neox 3D Optical Profiler (SSN09000) confocal microscope. The bone arrowhead was analyzed in a preliminarily fashion, given the lack of archeological and experimental referents. Scans were made using confocal technology of the piece both before and after the washing process.

A horizontal plan of bones and arrowheads illustrated the spatial distribution of these features as documented in the 2019–2021 field seasons (SI Figure S1). The distribution of the materials recovered during the archeological investigation of 1972–1973 was only partially documented, as drawings were made of the locations of the crania, ceramics, and bronze ornaments.

Radiocarbon dates were processed in OxCal 4.4.4. online software (Ramsey, 2009), using the IntCa20 calibration curve (Reimer et al., 2020). The dates were treated as a single group since stratigraphically there were no differences between the provenance of the remains in the cave. Bayesian modeling was carried out with the "Sum" function (Ramsey, 2017) to obtain the most probable chronological range.

4 | RESULTS

4.1 | Osteological study and bone trauma

A total of 3993 human remains were studied from the Roc de les Orenetes site, corresponding to an estimated MNE of 3126 (Table 2). According to the %MAU index, all human skeletal elements were represented in the assemblage in one quantity or another, but the most frequently represented bones were the tibia, femur, cranium, and mandible.

The estimated MNI of this burial assemblage is 51, with some of the most abundant elements being long bones, mandibles, and isolated teeth (Table 2). All age groups and both sexes were documented. Among the adults, five old adults (Table 3), 14 middle adults, 13 young adults, and seven adults of indeterminate age were documented. Twelve subadults were also identified, including three adolescents and nine children of different ages (Table 3). The sex distribution of

TABLE 2 Quantification of the analyzed human remains (NISP, percentage, MNE, MNI, and %MAU).

Element	NISP	%	NME	NMI	%MAU
Cranium	156	3.91	35	35	70
Mandible	68	1.70	47	47	94
Isolated Teeth	485	12.15	485	51	30.3
Hyoid	8	0.20	7	7	14
Clavicle	62	1.55	59	35	59
Scapula	120	3.01	36	23	36
Sternum	17	0.43	8	8	16
Rib	905	22.66	444	30	37
Vertebra	336	8.41	278	22	23.2
Sacrum	15	0.38	13	13	26
Coccyx	4	0.10	4	2	1.6
Os coxae	71	1.78	47	28	47
Humerus	150	3.76	60	48	60
Radius	79	1.98	66	36	66
Ulna	87	2.18	47	24	47
Carpal	109	2.73	109	13	13.6
Metacarpal	121	3.03	119	17	23.8
Hand phalanx	316	7.91	310	18	22.1
Femur	129	3.23	81	40	81
Patella	17	0.43	15	8	15
Tibia	179	4.48	100	51	100
Fibula	119	2.98	48	40	48
Tarsal	120	3.01	119	19	17
Metatarsal	149	3.73	142	25	28.4
Foot phalanx	159	3.98	157	9	11.2
Sesamoid	11	0.28	11	2	–
Thyroid cartilage	1	0.03	1	1	–
Total	3993	100	3126	51	–

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the individuals showed a marked imbalance, with a minimum of 24 males and seven females (including adults and adolescents over 15 years).

Perimortem injuries were observed on 26 bones (0.6% of NISP) (Table 4), corresponding to a MNE of 25 (0.8%). The MNI affected by these injuries is six (11.8% of total MNI). Of these six individuals bearing perimortem trauma, four are adults of indeterminate age (aged 20 years or older). The remaining individuals are two subadults, one adolescent (or late child) aged around 10–14 years, and one child between 4 and 7 years of age at death. Among the adults, at least two are males, and two are probable males. Although several long bones possess size and robusticity characteristics indicating that they derived from males, the absence of anatomical connections makes it impossible to associate different elements to the same individual. The distribution pattern of these lesions showed a marked predominance of injuries in the upper body (88.5%). The superior limbs (53.8%) and ribs (30.8%) are the most affected skeletal regions. As for laterality, an equal distribution of injuries was observed between the right (50%) and left side (50%) of the skeleton. A total of 49 lesions were observed in these 26 bones: 57.7% showed only one lesion, 34.6% between two and four, and 7.7% had five lesions or more.

One case of BFT was documented and the remainder were identified as SFT. All perimortem lesions are listed and described in Table 5. Among examples of sharp force trauma, we differentiate between more penetrating and blunt injuries (chop marks) as observed on 19 bones (73.1%), and injuries in the form of superficial linear incisions (slice marks), documented on six bones (23.1%). Chop marks never co-occurred with slice marks. The case of BFT was found on the only cranium with perimortem lesions (Ro73-5986) (3D model available at https://www.morphosource.org/concern/media/000516337?locale=en). This was middle-adult male, around 40–45 years of age at death, as estimated by dental wear. The traumatic defect is located on the center of the right temporal bone, just above the suprameatal crest (Figure 3). It is a depressed fracture, roughly circular in form, measuring 21.9 × 20.6 mm. Hinged bone fragments were still attached to part of the fracture margin.

Chop marks were found on 19 skeletal elements: clavicle ($n = 1$), humerus ($n = 7$), radius ($n = 3$), hand phalanx ($n = 1$), ribs ($n = 4$), vertebra ($n = 1$), femur ($n = 1$), and tibia ($n = 1$). In 90% of these cases, the trauma affected only the cortical bone tissue (Figure 4), without penetrating into cancellous bone. The exceptions are a fragment of a right humerus (Ro21-3375) in which the sharp force traumatic lesion reached the interior of the medullary cavity (Figure 5a), and a radius (Ro21-3453) with a transverse cut that bisected its diaphysis (Figure 6d). The latter case could represent an amputation of the forearm. The cases with the greatest number of lesions on the same bone were a right humerus (Ro20-1902), bearing nine chop marks at the center of the diaphysis (Figure 5b), and an 11th or 12th left rib fragment (Ro20-2034) with five cut marks on the superior and inferior

TABLE 3 Minimum number of individuals by age ranges documented in the osteological assemblage.

	Age range	MNI
Child	2–3	1
	4–5	1
	6–7	3
	8–10	2
Adolescent	11–12	2
	13–15	1
	15–16	1
	16–18	1
Adult	18–20	1
	20–35	12
	35–50	14
	+50	5
	+18	7

TABLE 4 Skeletal elements affected by perimortem trauma, types of injuries, and number of defects on the same elements.

Skeletal element	Bones with lesions	Bones with chop-marks	Number of chop-marks	Bones with slice-marks	Number of slice-marks	Blunt force trauma
Cranium	1	–	–	–	–	1
Clavicle	1	1	1	–	–	–
Scapula	1	–	–	1	3	–
Rib	8	5	11	3	3	–
Lumbar vertebra	1	1	1	–	–	–
Humerus	7	6	16	1	1	–
Radius	3	3	6			–
Ulna	1			1	1	–
Hand phalanx	1	1	1	–	–	–
Femur	1	1	2	–	–	–
Tibia	1	1	2	–	–	–
Total	26	19	40	6	8	1

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TABLE 5 Skeletal remains affected by sharp force trauma (SFT), age of the individuals, number of injuries, and description of the cut marks.

Element	Age and sex	Number of injuries	Description
Ro73-5986. Cranium, (Figure 3)	Adult, male	1	Blunt force trauma with depressed morphology, on the right temporal.
Ro73-4711.1. Humerus (L) (Figure 4a)	Adult, male	2	Two chop marks, one on the posterior midshaft, and another slighter on the medial aspect of the proximal diaphysis. Both lesions have a transverse-oblique orientation and distal direction.
Ro19-1015. Clavicle (L) (Figure 4b)	Adult	1	Oblique SFT near the distal epiphysis, superior aspect, next to the posterior border, in the trapezius muscle tuberosity, with anterolateral direction.
Ro21-3469. Humerus (L) (Figure 4c)	Adolescent	3	Three chop marks on the proximal half of the diaphysis, posterior aspect. Lesions produced by the impact with a very oblique inclination of the cutting object, with distal direction. One of the defects, the most proximal, raised a peeling of 14 mm in length.
Ro73-6363. Humerus (L) (Figure 4d)	Adult	1	Chop mark on the distal half of the diaphysis, anteromedial aspect, with transverse-oblique orientation, and distal direction.
Ro21-3375. Humerus (R) (Figure 5a)	Adult	2	Sharp-blunt trauma of great intensity, reaching the medullary cavity, on the medial aspect, with distal direction, and another chop located more proximal, on the anterior aspect, and proximal direction.
Ro20-1902. Humerus (R) (Figure 5b)	Adult	9	Nine slight chop marks on the medial border of the midshaft, in a sub-parallel position and transverse orientation, with proximal direction.
Ro20-2085. Humerus (R) (Figure 5c)	Adult	1	Slight chop mark on the anterior aspect, next to the lateral supracondylar crest.
Ro20-1960. Radius (R) (Figure 6a)	Adult, probably male	2	Two lesions on the center of the diaphysis, posterolateral aspect. A very oblique chop mark, with transverse orientation and proximal direction, and penetrating SFT with oblique orientation and directed almost vertically to the midshaft.
Ro20-2126. Radius (L) (Figure 6b)	Child (5–7)	1	Chop mark on the anterior aspect of the midshaft, with oblique-transverse orientation.
Ro20-1909. Hand phalanx (L) (Figure 6c)	Adult	1	Proximal phalanx, finger 3–4, with chop mark on the dorsal aspect, with proximal direction. The blow generated a peeling of the cortical bone.
Ro21-3453. Radius (R) (Figure 6d)	Adolescent	3	Three injuries: (1) chop mark on the anterior aspect of the proximal diaphysis, with sub-triangular morphology, (2) SFT on the center of the diaphysis, in the medial crest, with oblique orientation, and (3) SFT of great intensity that cut the entire diaphysis with an oblique-transverse orientation, sectioning the forearm in half, in a proximal direction.
Ro21-3246. Rib 4th–7th (L) (Figure 7a)	Adult	1	Chop mark on the lower border, distal half of the midshaft.
Ro73-6595 & Ro73-6677. Rib 6th–8th (R) (Figure 7b)	Adult	3	Three chop marks on the lower border, two of them contiguous in the angle, and another towards the midshaft.
Ro20-2034. Rib 11th–12th (L) (Figure 7c)	Adult	5	Three chops on the lower border, and two on the upper border, directed proximally.

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TABLE 5 (Continued)

Element	Age and sex	Number of injuries	Description
Ro21-3259. Rib 8th–9th (R) (Figure 7d)	Adult	1	Chop mark on the upper border of the angle, with crushing coming from above.
Ro21-3324. Rib 9th–10th (R) (Figure 7e)	Adult	1	Chop mark on the lower border of the angle.
Ro20-1606. Femur (R) (Figure 8a)	Adult	2	Two chop marks on the anterior aspect of the proximal diaphysis, with transverse orientation and proximal direction.
Ro21-3526. Tibia (L) (Figure 8b)	Adult	2	Two chop marks on the anterior crest of the midshaft. The bigger one (more proximal) removed a bone fragment, and its lower border is splintered and slightly raised by the impact.
Ro21-3479. Vertebra (L5) (Figure 8c)	Adult	1	Deep SFT between the left superior articular aspect and the left transverse process.
Ro73-6873. Scapula (L) (Figure 9a)	Adult	3	Three slice marks with oblique orientation on the posterior aspect of the scapular spine, measuring 16, 4, and 6 mm. The marks have an inferior, superior, and probably inferior direction, respectively.
Ro20-1762. Rib 4th–8th (L) (Figure 9b)	Adult	1	Slice mark on the internal surface of the shaft, with oblique orientation.
Ro73-6325. Humerus (L) (Figure 9c)	Adult, male	1	Longitudinal slice mark on the midshaft, posterior aspect, 99 mm long, from the center of the diaphysis to the beginning of the medial crest.
Ro73-6442. Rib 4th–7th (R) (Figure 9d)	Adult	1	Slice mark on the outer surface of the rib angle, with oblique orientation.
Ro21-3497. Ulna (L) (Figure 9e)	Child (5–7)	1	Slice mark on the posterolateral aspect of the distal diaphysis.
Ro73-6520. Rib 4th-7th (R) (Figure 9f)	Adult	1	Longitudinal and wide slice mark on the outer surface of the midshaft, 43 mm long, with distal direction.

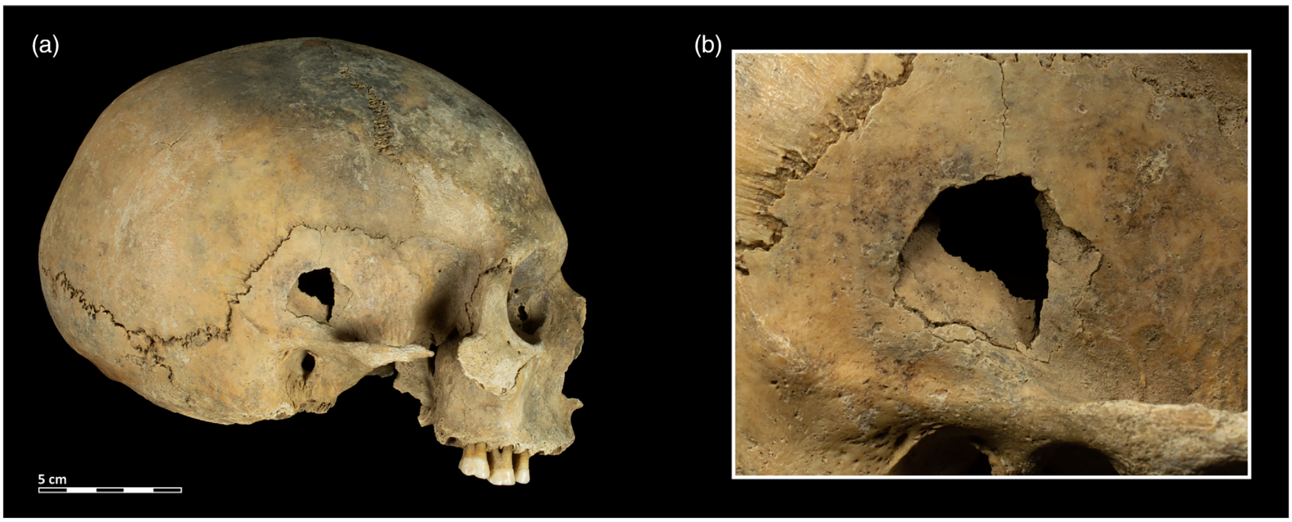

FIGURE 3 (a) Cranium Ro73-5986 from Roc de les Orenetes showing a blunt force trauma (BFT) on the right temporal bone and (b) close view of the fracture.

edges (Figure 7c). On the long bones, the injuries were found on the diaphyses in all cases (Figure 8).

Slice marks were found on six bones: scapula ($n = 1$), ribs ($n = 3$), humerus ($n = 1$), and ulna ($n = 1$). The left scapula Ro73-6873 featured three slice marks on the posterior aspect of the scapular spine (Figure 9a) while the rest of the remains showed just one slice mark. Four marks were less than 10 mm long, while one slice mark on the scapula measured 15 mm. A

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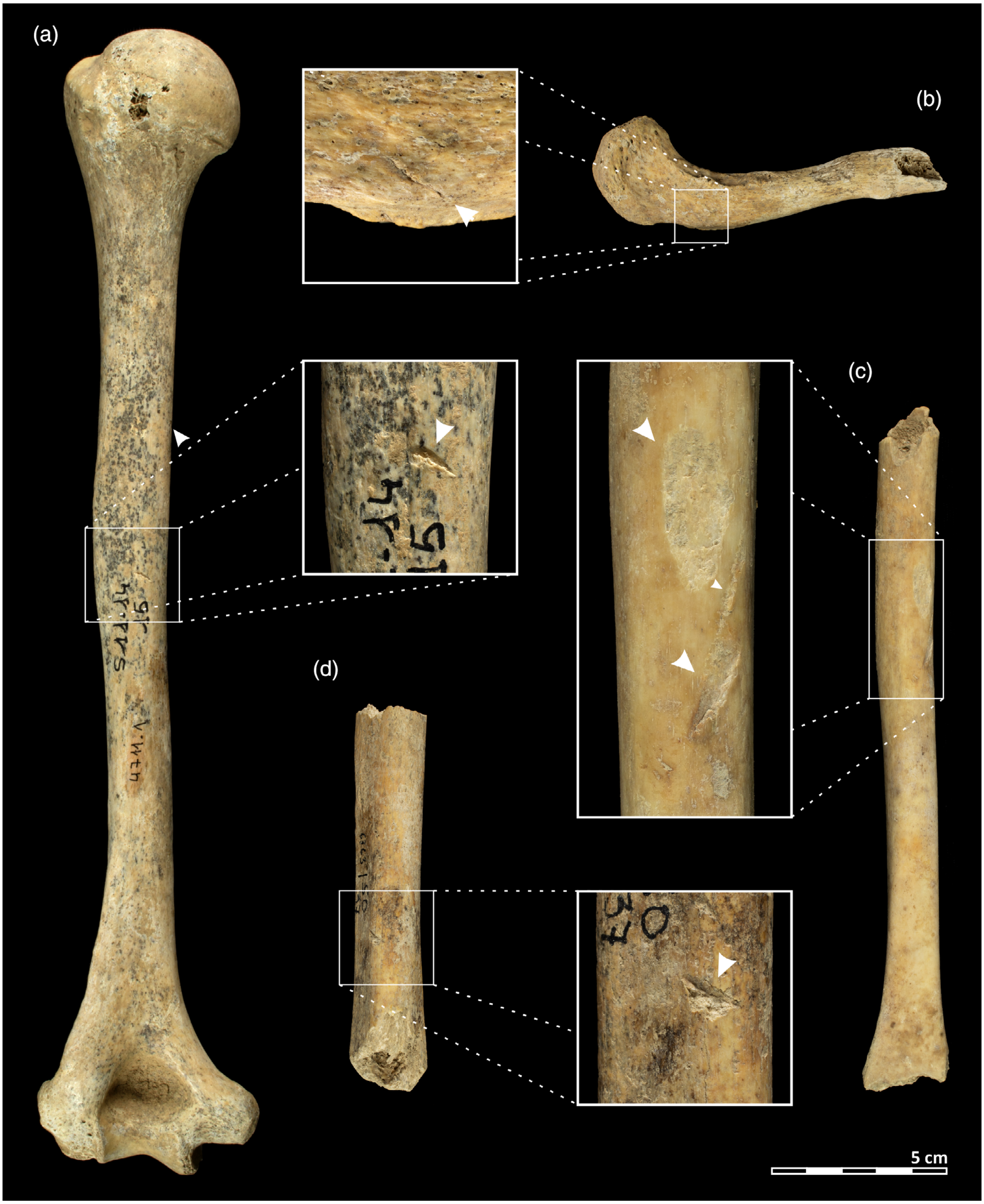

FIGURE 4 Humeri and clavicle showing chop marks. (a) Left humerus Ro73-4711.1; (b) left clavicle Ro19-1015; (c) left humerus Ro21-3469; and (d) left humerus Ro73-6363.The arrows indicate the direction of the blows.

humerus (Ro73-6325) showed a longitudinal slice mark on the posterior aspect of the diaphysis (Figure 9c), measuring 99 mm, from the midshaft to the distal part of the diaphysis, and rib Ro73-6520 had a longitudinal slice mark (Figure 9f) 56 mm long, and at most 5 mm wide. These last two cases were defined as scraping marks.

Antemortem lesions probably related to intentional blows or fractures were also found on six skeletal elements, five crania, and one ulna. All documented antemortem cranial trauma consisted of small depressions on the external table (Figure 10), between 10 and 5 mm in diameter. These kinds of injuries were observed on three frontal bones, two right parietal bones, and one on a right side

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FIGURE 5 Humeri with chop marks. (a) Right humerus fragment Ro21-3375 (the yellow arrow indicates the heavy SFT that penetrated the medullary cavity); (b) right humerus Ro20-1902 with multiple chop marks; and (c) fragment of right humerus Ro20-2085. The arrows indicate the direction of the blows.

coronal suture. Four of these crania were estimated to be male according to their morphological characteristics, and one was likely female. The fragment of left ulna Ro73-7291 had an antemortem transverse fracture of the distal diaphysis (Figure 11) (Agustí, 1999; Mercadal & Agustí, 2006). It was an oblique fracture, and the distal end of the forearm was missing. The fractured surface was

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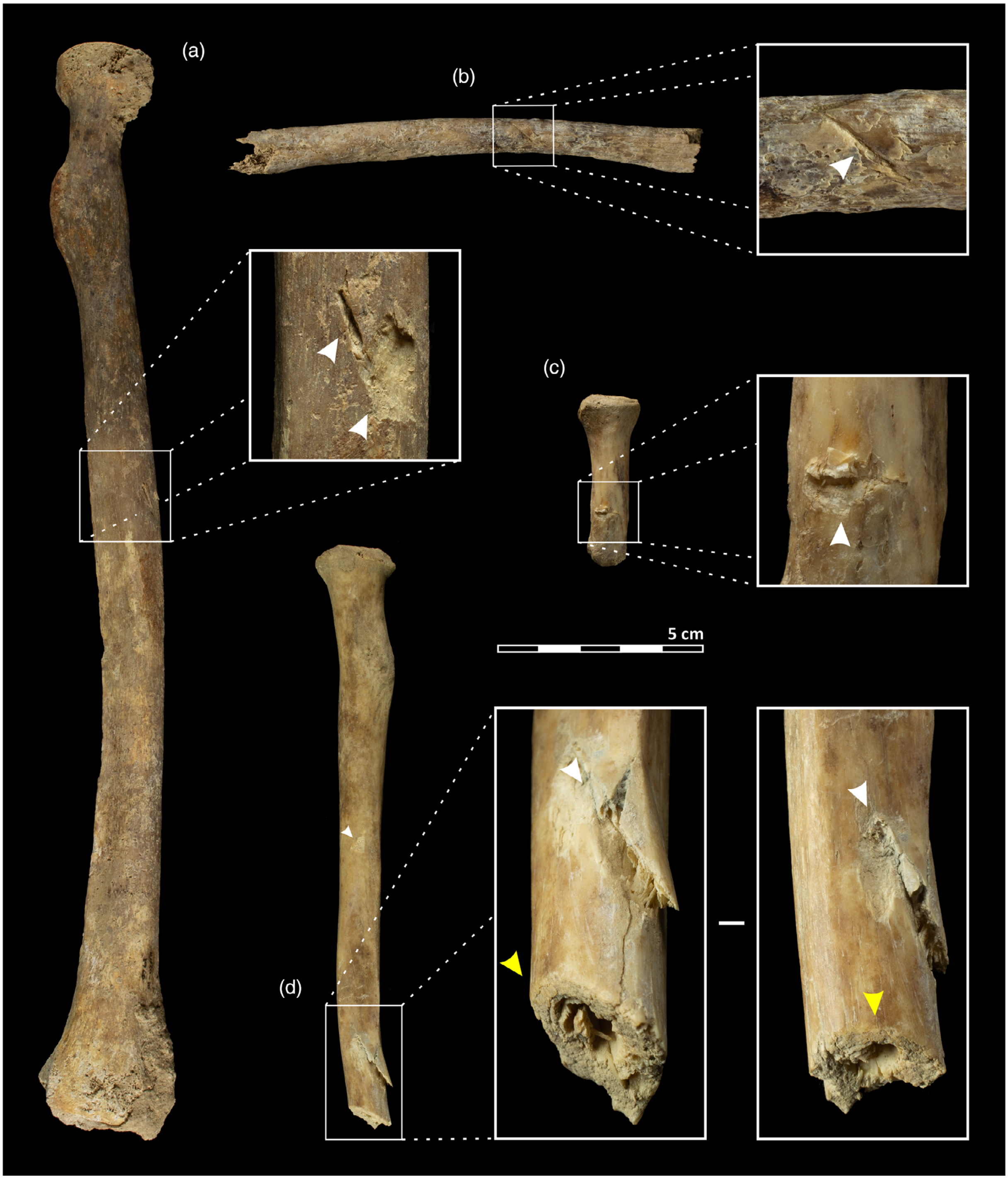

FIGURE 6 Forearm elements with chop marks. (a) Right radius Ro20-1960; (b) subadult left radius Ro20-2126; (c) left proximal phalanx Ro20-1909; and (d) juvenile right radius Ro21-3453 showing three chop marks, with the heaviest transecting the forearm (yellow arrow). The arrows indicate the direction of the blows.

completely remodeled, with no signs of development of pseudoarthrosis. This case may well represent an amputation of the hand and part of the inferior upper limb.

The horizontal distribution of the bones on the excavated surface showed a mostly random dispersion of the remains (SI, Figure S2). Although the skeletal remains were found disarticulated and commingled, their horizontal distribution revealed proximity of some bones belonging to the same individual, located in the same square. Bones bearing sharp force trauma and projectile points were scattered throughout the excavated area.

4.2 | Projectiles use-wear analysis

Use-wear analysis of the projectile points revealed that at least some of them featured impact breakages. Two of the chert pieces received

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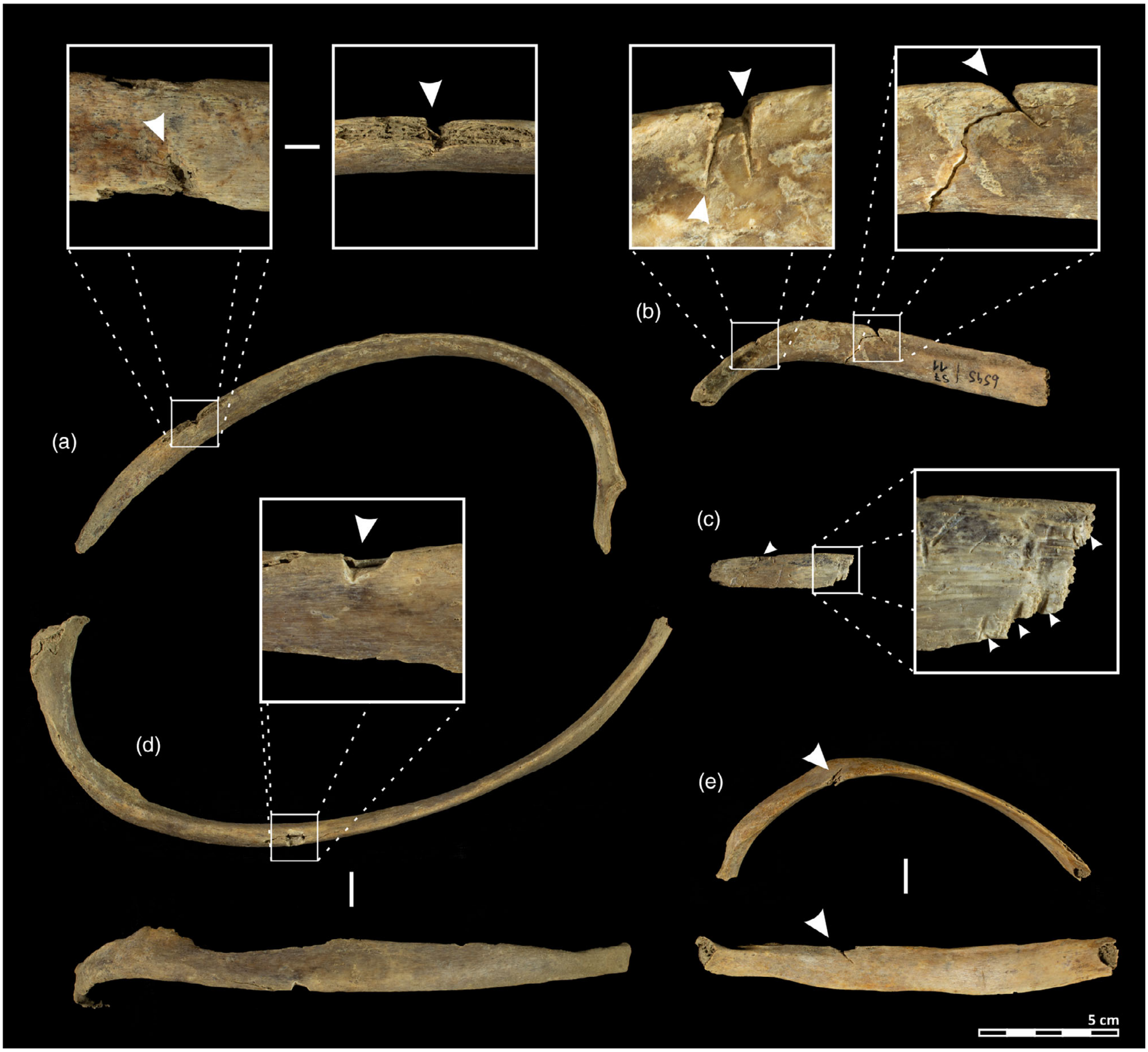

FIGURE 7 Ribs with chop marks. (a) Left rib Ro21-3246; (b) right rib Ro73-6677/6595 with three stabbing chop marks, two of them contiguous, between the neck and the angle of the rib, and one towards the midshaft; (c) left rib fragment Ro20-2034 with multiple chop marks; (d) right rib Ro21-3259; and (e) right rib Ro21-3324. The arrows indicate the direction of the blows.

no further study due to their poor state of preservation (Ro19-1430 and Ro19-1431) (Figure 12a,b). Both pieces were completely eroded by weathering, and the ridges of the retouch removals even disappeared. Although these two pieces show apical and barb fractures it cannot be ruled out that they were broken post-depositionally. The three remaining artifacts, despite their metric and formal variability within the barbed and tanged arrows group, show diverse evidence of use.

The chert point Ro21-2840 (Figure 12c) is the one with the most functional evidence of having been used as a projectile. In this case, the high number of marks and their various locations indicate repeated use. At a macroscopic level, a large bifacial spin-off eliminated a large part of the distal area on both sides (Figure 13a,b). The evidence of reuse is based above all on the presence of several bright-spots aligned at different areas of the piece (Figure 13c–e). Bright-spots are areas of polish generated by high-intensity friction which are generally related to the process of hafting (Rots, 2002). Some of these spots were split by later scars, both by distal fracturing (including the spin-off) and by the fracture generated by the blowback of the shaft. Several bright-spots are in turn altered by MLIT of various sizes that always maintain the longitudinal directionality to the maximum axis of the piece following the direction of penetration of the arrow. The barbed areas of the piece also show some bright-spots with striations and polishing generated by the shaft at the base of the barbs. Additional abrasions on the sides and internal areas of the barbs were produced by the preparation and fixing of the piece to the shaft.

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FIGURE 8 Elements of the lower appendicular skeleton (and one vertebra) showing chop marks. (a) right femur Ro20-1606; (b) left tibia Ro21-3526; and (c) lumbar vertebra (L5) Ro21-3479.

The smaller piece of chert provided information on the recovery, resharpening, and recycling, as well as the multiple functions of its pointed morphology (Figure 12d). The piece shows in its central area (on both sides) the remains of the heat treatment by which the original projectile point was probably made. Possibly, after the fracture of the tool, this piece had been resharpened, generating the shape in which it appears today, permitting observation of a double central patina. In addition, the thickness of the piece is similar to that of the larger pieces, so it was most likely an arrowhead that was reconditioned from the various fractures produced during use (Palomo, 2002). The only microscopic marks observable on the distal area are related to its use to perforate some material of relatively significant hardness, such as hard wood or bone. After this, an impact occurred that generated a complex lateral fracture (Coppe & Rots, 2017) that removed part of the polish produced from rotational movement (Figure 13f,g).

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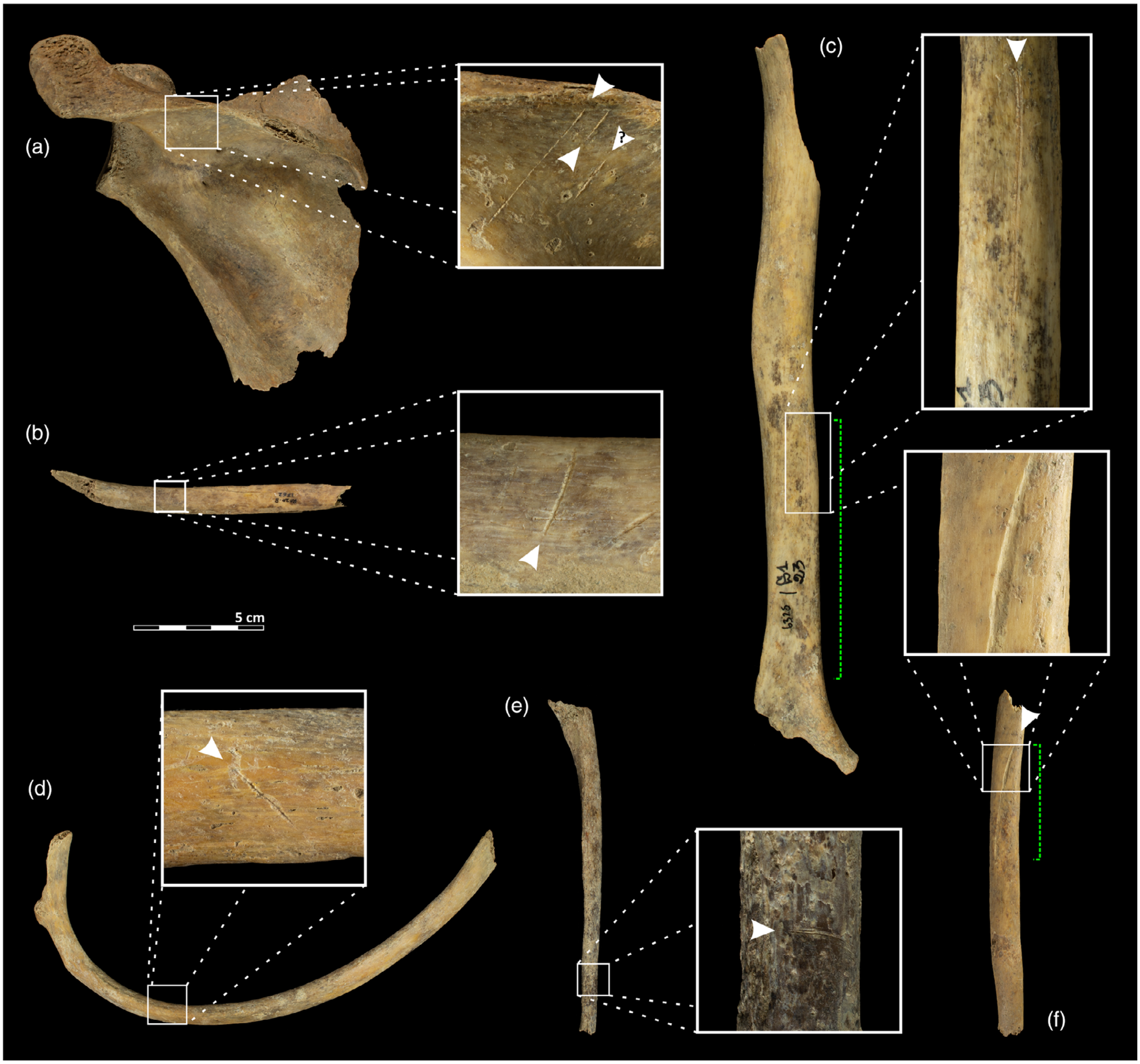

FIGURE 9 Bones with slice marks. (a) Left scapula Ro73-6873; (b) left rib fragment Ro20-1762 showing a slice mark on the inner surface; (c) left humerus Ro73-6325 with a longitudinal slice or scrape; (d) right rib Ro73-6442; (e) subadult left ulna Ro21-3497; and (f) right rib fragment Ro73-6520 with a longitudinal and wide scrape mark. The arrows indicate the direction of the cuts.

Finally, the bone arrowhead shows what appears to be a simple oblique fracture of the tip along with scarring of the surface towards the interior of the piece that can be categorized as a spin-off fracture (Figure 12e). On the other side of the piece, in addition to the linear marks produced by polishing during the fabrication of the piece, a series of MLIT was observed. These arise from the fracture in a slightly oblique disposition, most probably related to the impact of the arrowhead as a projectile.

5 | DISCUSSION

Roc de les Orenetes contains a collective burial with a minimum of 51 individuals dated between the Late Chalcolithic and Early Bronze Age, in which clear evidence of interpersonal violence was observed. Previous studies of the materials from the excavations in the 1970s estimated a lower MNI of 32 (Agustí, 1999) or 37 (Toledo & Pons, 1982). Since in those studies, the available remains comprised only the largest bones of the skeleton, mainly recovered on the surface of the cave floor during the 1970s. It was a biased sample. Agustí (1999, p. 201) considered the possibility that these were remains of a secondary burial, due to the absence of the smallest skeletal elements, such as phalanges, carpals, isolated teeth, or very fragmented bones. However, additional remains were recovered during systematic excavation between 2019 and 2021. This indicates that there was no intentional selection of the skeletal remains, as occurs in secondary burials, where normally only larger bones or specific elements reach the final burial place. On the contrary, the pattern of

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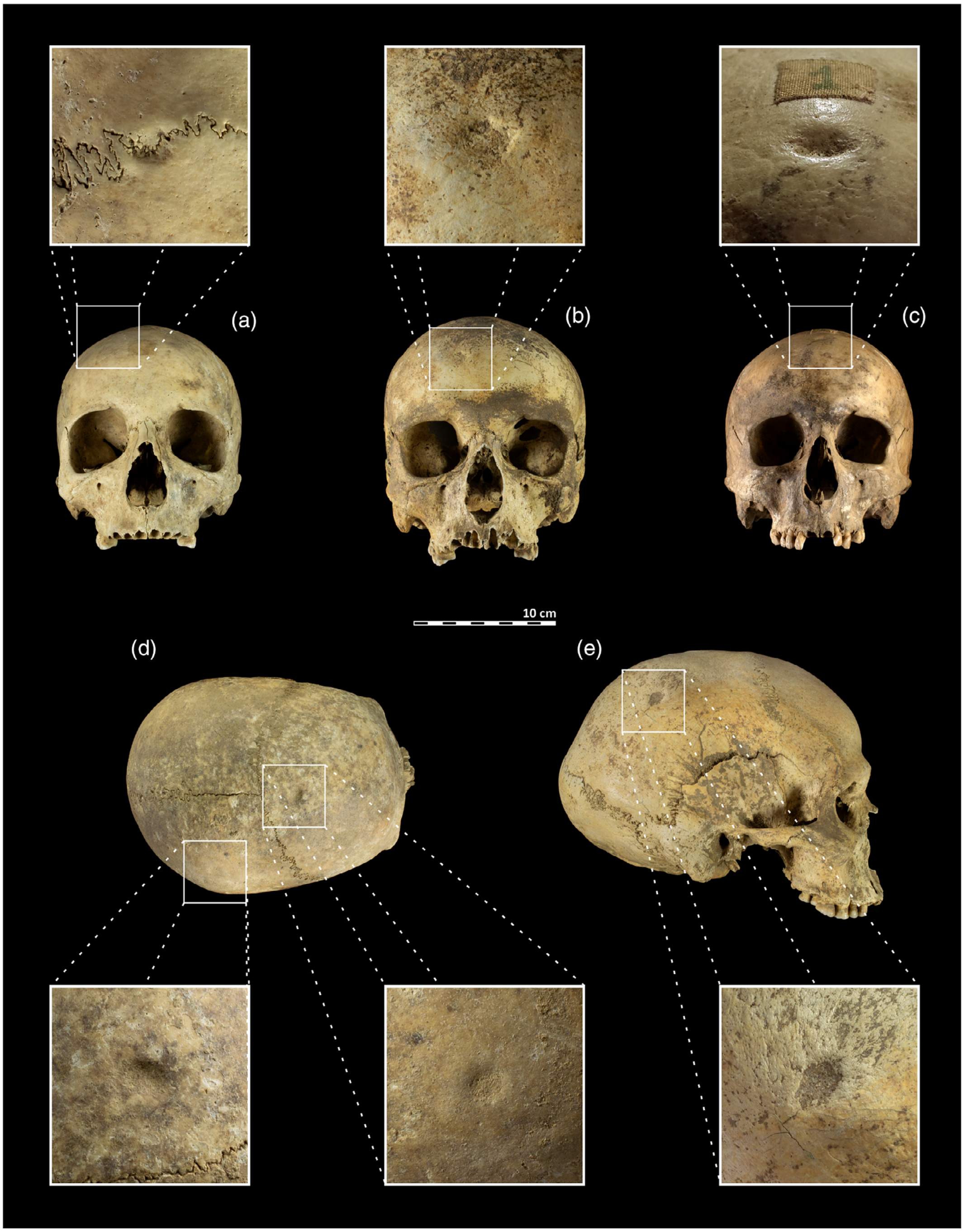

FIGURE 10 Antemortem cranial trauma. (a) Cranium Ro73-5878.1, adult female, 30–40 years of age at death; (b) cranium Ro73-5985, adult male, 30–40 years of age at death; (c) cranium Ro73-3692, adult male, 35–45 years of age at death; (d) cranium Ro73-6236, young adult male, 20–30 years of age at death; (e) cranium Ro73-6045, adult male, 40–50 years of age at death.

skeletal representation is typical of primary burials in which the bodies arrived complete in the cave and is where they decomposed.

Taphonomic analysis of the remains showed that scavenging carnivores were the main agent responsible for the disarticulation and fragmentation of the assemblage. This is a common situation in prehistoric collective burials, together with the successive reuse of the space for new inhumations that invariably disturb earlier skeletons (Adams & Byrd, 2014; Schmitt, 2022; Tomé et al., 2017). Both the type of analysis and the sample available to study can completely change the interpretations and conclusions drawn about the funerary practices carried out at the site, and the remains recovered during the 1970s were not a sufficiently representative sample of the collective burial of Roc de les Orenetes. Although this site was included in two doctoral theses (Agustí, 1999; Toledo, 1990) and two specific anthropological and paleopathological studies (Campillo, 2001; Mercadal & Agustí, 2006), the sharp and blunt force trauma present in some of the osteological remains had not previously been identified.

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FIGURE 11 Left ulna fragment Ro73-7291 with evidence of amputation and remodeling of transected end. The radiographic image shows complete healing of the bone tissue.

5.1 | Antemortem trauma

We have identified a wide range of traumatic lesions. Healed antemortem injuries do not provide information about the manner of death, but they inform us about the involvement of individuals in nonfatal violent confrontations during their lifetimes.

All antemortem cranial trauma lesions (Figure 10) are located on the cranial vault, above the so-called Hat Brim Line (HBL). According to the HBL rule (Guyomarc'h et al., 2010; Kranioti, 2015; Kremer et al., 2008; Kremer & Sauvageau, 2009), injuries located above this band of about 30 mm, which corresponds to the maximum circumference of the cranial vault, are more often related to intentional blows than to falls or accidents in 70%–80% of cases. Furthermore, depressed fractures are commonly produced by intentional blows with an object with a narrow striking surface, while linear fractures are more often related to impacts on large surfaces, as can occur in accidental falls (Cohen et al., 2014; Jiménez-Brobeil et al., 2009; Lovell, 1997; Tersigni-Tarrant, 2015; Wedel & Galloway, 2014).

Antemortem cranial lesions found at Roc de les Orenetes are very small and would be generally consistent with relatively light blows, produced by objects with a narrow or pointed surface. These blows caused a subperiosteal hemorrhage and subsequent depression on the external cortical surface, thus not affecting the internal table of the cranium or causing significant damage to the internal soft tissues. This type of trauma is very abundant in the archeological record at different times (Cohen et al., 2014; Fibiger et al., 2013; Gummesson et al., 2018; Jiménez-Brobeil et al., 2009; Moreno-Ibáñez et al., 2021; Owens, 2007; Sala et al., 2022; Schulting & Fibiger, 2012; Schulting & Wysocki, 2005; Smith, 2017; Wu et al., 2011). It has sometimes been related to occasional skirmishes between individuals and small groups, in which the intention was probably not to cause death (Dyer, 2019; Fibiger et al., 2013; Schulting & Fibiger, 2012; Schulting & Wysocki, 2005). Both the characteristics of these lesions and their location on the cranium indicate a more likely relationship with low-intensity interpersonal confrontations experienced by the individuals throughout their lives.

The ulna fragment represents a case of complete antemortem fracture of the diaphysis, with the absence of the distal end of the bone (Figure 11). Fractures of the middle or distal third of the ulna can be caused by falling against the forearm, but it is also the most frequent location when parrying a blow to protect oneself from an attack. This is why they are called “parry fractures” (Judd, 2008; Lovell, 1997; Moraitis & Spiliopoulou, 2006; Redfern & Roberts, 2019; Wedel & Galloway, 2014). Due to the high kinetic energy of a blow required to cause a complete fracture and absence of pseudoarthrosis (Khudaverdyan, 2014; Redfern & Roberts, 2019; Roksandic et al., 2006; Tucker et al., 2017), it can be hypothesized that the distal part of the forearm was amputated. This could have

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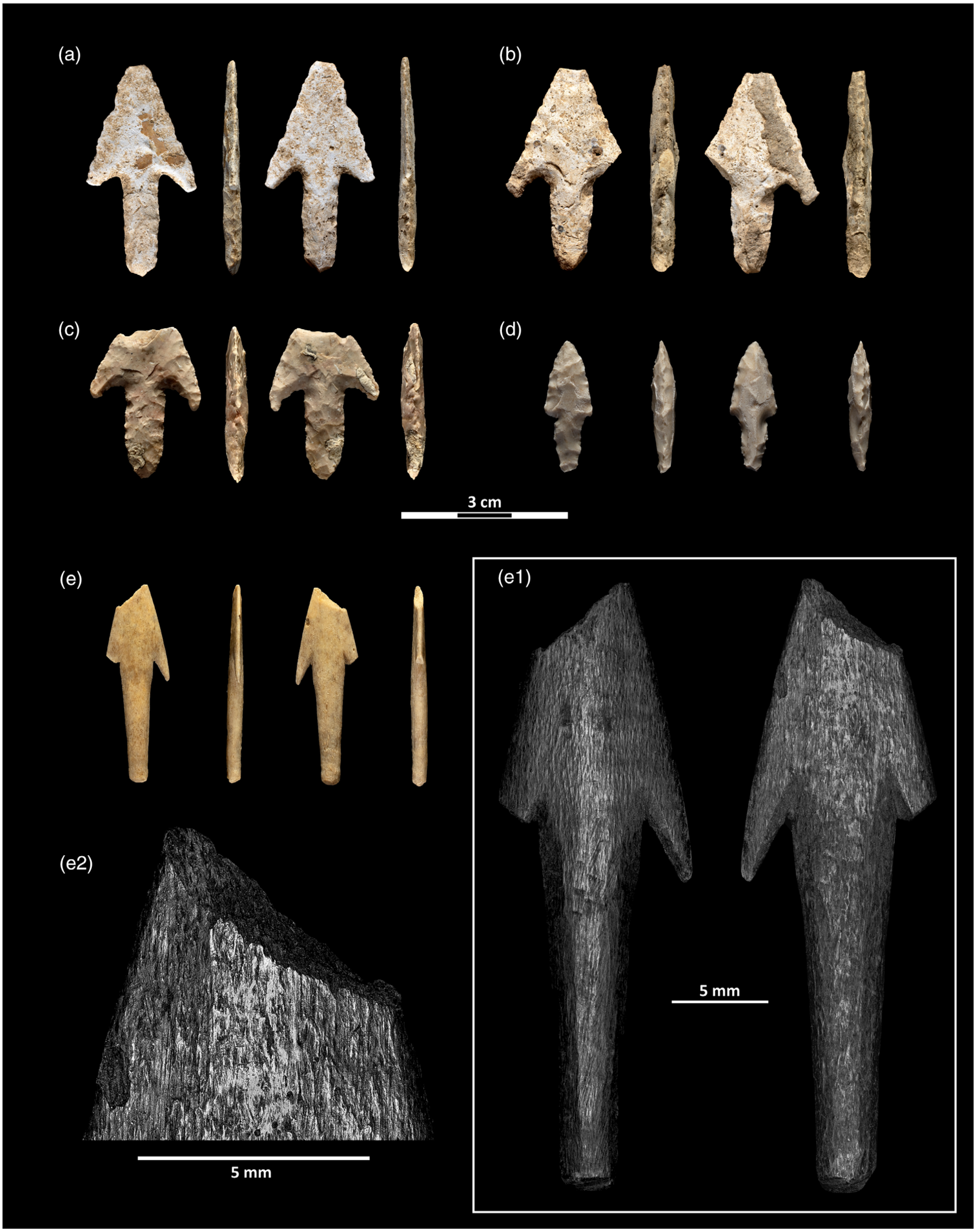

FIGURE 12 Arrowheads from Roc de les Orenetes. (a–d) Chert barbed and tanged points. (e) Bone barbed and tanged point. Points Ro19-1430 (a) and Ro19-1431 (b) showed severe post-depositional effects that did not allow microscopic analysis. (c) Point Ro21-2840 shows a distal impact fracture. (d) Recycled point with persistence of thermal patina in the central area of both faces. (e) Bone arrowhead; scanning of its surface with the confocal microscope (e1), and detail of the Spin-Off type impact fracture, consisting of an oblique transverse fracture from which longitudinal removals depart in the distal zone (e2).

been done with a single cut made with a bladed weapon, and/or bending the bone. Comparable evidence of amputations are not very abundant in the prehistoric archeological record, but some are known from the Iron Age (Cohen et al., 2015; Fernández-Crespo et al., 2020), Bronze Age (Bloom et al., 1995), Chalcolithic (Zäuner et al., 2013), Neolithic (Buquet-Marcon et al., 2007; Crubézy, 1996; Grupe &

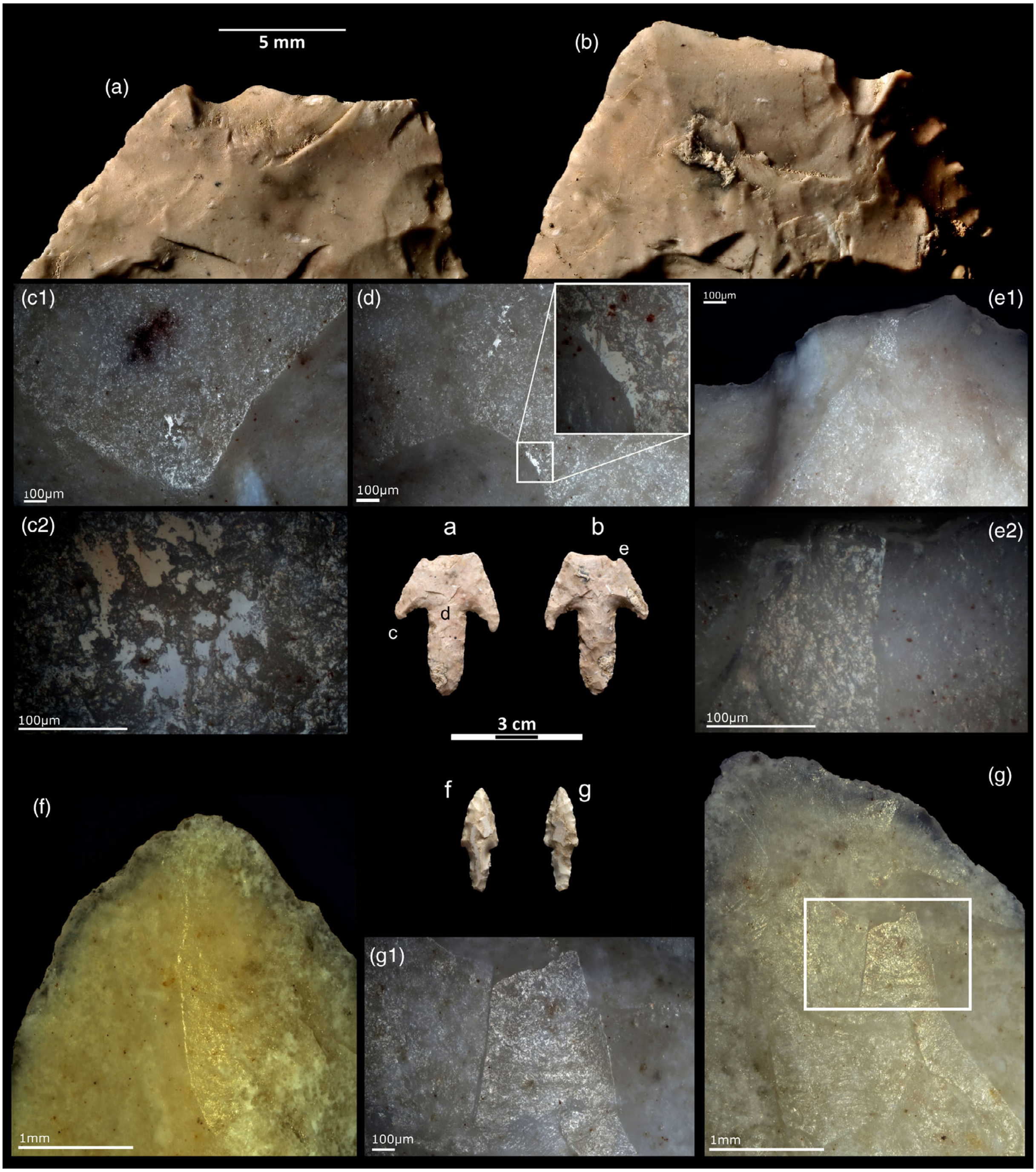

FIGURE 13 Use-wear analysis of arrowheads Ro21-2840 and Ro20-1718. Point Ro21-2840 showed (a, b) a bifacial Spin-Off fracture related to a projectile impact, (c) rounding of the barb with an intense bright-spot with MLIT superimposed, (d) partially detached bright-spot of hafting with MLIT superimposed, and (e) distal MLIT associated with the impact. The point Ro20-1718 showed (f-g) polishing on the distal ridges on both faces of the point associated with rotational movement, and (g) a distal fracture with cracking that removed part of the previous polishing.

Herrmann, 1986), and the Upper (Maloney et al., 2022) and Middle Paleolithic (Estabrook & Frayer, 2014; Trinkaus & Zimmerman, 1982).

Amputations are usually interpreted as a surgical intervention following non-union of a fracture caused by severe trauma (Maloney et al., 2022; Trinkaus & Zimmerman, 1982; Zäuner et al., 2013), in which cutting implements may have been used to separate the forearm. In this case, since the healed surface has an oblique angle, a weapon-induced amputation constitutes the most likely scenario rather than a surgical intervention. The presence of multiple antemortem and perimortem injuries in the site also supports the possibility of violence surrounding this antemortem amputation. It is expected that the radius was also affected and also amputated, but this element has not been found so far at the site. Excavation is still ongoing but considering that the site is highly affected by carnivore activity and multiple post-depositional taphonomic processes, the corresponding radius may never be found.

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5.2 | Perimortem trauma: Violence or secondary funerary treatment?

Among the perimortem injuries, a single case of BFT was identified in the right temporal bone of a cranium (Figure 3). A depressed fracture with a concentric diameter (21.9 mm) must have been produced by an object with a surface of similar size. The zygomatic arch was not affected, so the possibility of an accidental fall against a large surface, such as the ground, can be ruled out (Tersigni-Tarrant, 2015; Wedel & Galloway, 2014). To produce this type of fracture, objects such as antlers (Ahlström & Molnar, 2012; Schulting & Wysocki, 2005), metal spears (Erdal, 2012; Jantzen et al., 2011), wooden stakes (Gummesson et al., 2018), or simply stones of variable morphology, either hafted as a mace or hand-held could be responsible (Dyer, 2019; Fibiger et al., 2013; Madden et al., 2018; Martin & Harrod, 2015; Schulting & Wysocki, 2005).

Different blunt objects can cause identical fracture patterns, so it is not always possible to determine the exact weapon used without risking over-interpretation (Pinheiro et al., 2015; Spatola, 2015). This case does not seem to be related to the use of a sharp-blunt object, such as an ax or adze, because of its circular and homogeneous outline that makes it difficult to distinguish a clear point of impact from an object with sharp ends (Kimmerle & Baraybar, 2008; Moreno-Ibáñez et al., 2021, 2023). It is possible to posit that this is a BFT produced by an object with a small surface area, which impacted just above the ear of the individual, and which was probably the cause of death. If we take into account the high percentage of the right-handed population (Coren & Porac, 1977; Kranioti, 2015), and that the traumatic lesion is located on the right temporal bone, it is likely that the attack occurred from the individual's back. Additionally, a backhanded blow, or a face-to-face confrontation with a left-handed attacker, are also possible (Kranioti et al., 2019; Madden et al., 2018).

The rest of the perimortem injuries are SFT. In this category, mainly chop marks on long bones are observed, but also some superficial slice marks. Between both types of sharp force trauma, there are a total of 26 affected bones, belonging to a minimum of six individuals, five adults, one juvenile (around 15–20 years), and one child (around 5–7 years). The injuries are mostly found in the upper body, especially on the upper limbs and ribs (Figure 14), although in some cases they are also found in the lower body. One of the first questions regarding this type of cut mark is if they are related to interpersonal violence or secondary processing of the bodies during funerary treatment. The characteristics observed in the injuries, their skeletal distribution, and their comparison with other similar archeological sites in Europe, forensic cases and experimental studies, lead us to reject the possibility of secondary funerary treatment of the bodies, with which some of the marks could be confused.

The practice of defleshing bodies and disarticulating limbs and heads is well-known from the Neolithic period in funerary contexts, with multiple documented cases, both in Europe (Belcastro et al., 2021; Crozier, 2016; Fowler, 2010; Geber et al., 2017; Mariotti et al., 2020; Nicolosi et al., 2023; Robb et al., 2015; Wallduck & Bello, 2016) and the Near East (Erdal, 2015; Santana et al., 2012, 2015; Simmons et al., 2007). The main difference between the marks found at Roc de les Orenetes and those cases interpreted as a secondary treatment of the body is their distribution and abundance on the skeleton. In the cases in which the body is processed to disarticulate the limbs or remove soft tissues, the cuts are preferentially or exclusively, located in the joint areas or muscle attachment points (Belcastro et al., 2021; Cohen et al., 2015; Crozier, 2016; Duday, 2009; Erdal, 2015; Geber et al., 2017; Hurlbut, 2000; Pérez, 2012; Robb et al., 2015; Santana et al., 2015), such as the shoulder, elbow, hip, and knee. It is common in these cases to find more than one cut mark on each bone mainly in the form of slice marks (but sometimes chop marks as well) forming groups of marks in the same direction relating to repetitive movements involving cutting soft tissue or separating one body element from another.

The same repetition of actions to disarticulate, remove the flesh, or to eviscerate, are observed in cannibalized skeletal remains (Andrews & Fernández-Jalvo, 2003; Bello et al., 2015; Cáceres et al., 2007; Hurlbut, 2000; Saladié et al., 2012; Saladié & Rodríguez-Hidalgo, 2017; Turner & Turner, 1999; White, 1992). In cannibalized remains, there is an even higher frequency of cut marks than in skeletons processed for funerary or ritual reasons (Hurlbut, 2000; Saladié & Rodríguez-Hidalgo, 2017). In this case, we did not observe a pattern of butchery and processing typical of cannibalism neither in the quantity and distribution of the cut marks, fracture patterns indicative of disarticulation, negative evidence of cooking, or the presence of human tooth marks.

The sharp force trauma found in the Roc de les Orenetes assemblage consist of isolated chops and slices in most cases and are generally not found in major joint areas of tendon attachments. The number of cuts is relatively low compared to other archeological cases interpreted as postmortem processing of the remains, such as those from Körtik Tepe in Anatolia. There, slice marks form groups of at least nine marks, up to a maximum of 135 slice marks on the same bone (Erdal, 2015), or the case observed in Carrowkeel complex in Ireland, where 91 slice marks were documented on 12 bones (Geber et al., 2017). Therefore, these injuries documented in Roc de les Orenetes appear unrelated to butchery activities or postmortem processing of the remains, but to a pattern of violent trauma caused by cutting objects or weapons.

The bones from Roc de les Orenetes that show cut marks near articular areas are the left clavicle Ro19-1015 (Figure 4b) and the left scapula Ro73-6873 (Figure 9a). The first case is an isolated cut mark next to the acromioclavicular joint with a combination of chop and slice mark features. It is located on the superior aspect of the lateral end, in the rugosity of the trapezius muscle. The inclination of the cut indicates that it was made across the individual's back, with a straight and penetrating beginning of the mark, similar to a chop, and the exit is located anteriorly, showing superficial and curved striae (SI, Figure S3). These characteristics would relate this injury to the impact of a sharp object on the posterior shoulder, but not with the intention of disarticulating the arm, in which case many more marks would be expected. The scapula, however, might raise more

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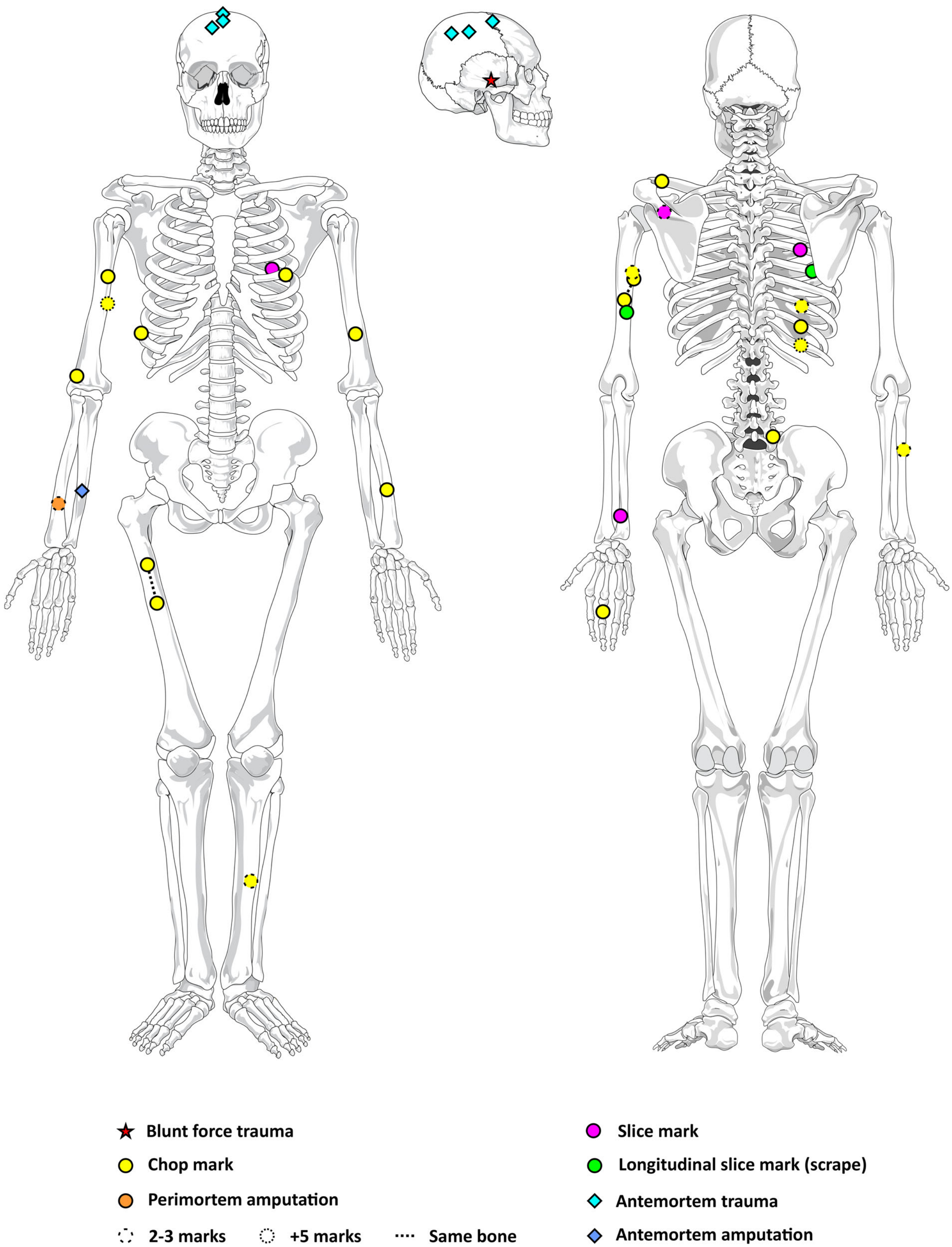

FIGURE 14 Pattern of skeletal distribution of antemortem and perimortem trauma.

doubts about the nature of the cut marks. They are three cuts on the posterior aspect of the scapular spine and could be related to sectioning the deltoid muscle to achieve separation of the left upper limb.

There are several known cases in the archeological record of scapulae with cut marks, either from secondary funerary treatment (Mariotti et al., 2016; Russell, 1987), or from consumption (Andrews & Fernández-Jalvo, 2003; Bello et al., 2015; Boulestin & Coupey, 2015;

Cáceres et al., 2007; Saladié et al., 2012), but in both cases, they present a large number of marks, generally short and forming groups, which are commonly located on the neck, the lateral border of the scapular spine, and the lateral edge of the scapular blade. When the objective is to cut the attachment of the deltoid muscle, the cuts have a generally transverse orientation in the infraspinous fossa and the spine of the scapula (Bello et al., 2015; Boulestin & Coupey, 2015; Mariotti et al., 2016; Russell, 1987). In this case, we observed just three parallel slice marks, slightly separated from each other, one of them longer, reaching 16 mm in length. It is not possible to completely rule out that these marks are related to the disarticulation of the upper limb in secondary funerary treatment. However, considering the rest of the marks documented at the site, it is highly probable that they are, in fact, sharp force trauma related to a repetitive attack from behind the individual with a sharp implement. The microscopic observation of these slice marks indicates that they were performed with alternating motions (SI, Figure S4). The longest slice mark was made with a superoinferior movement, the central one from an inferosuperior direction, and the more medial mark could have been made with a superoinferior movement.

The remainder of the chop and slice marks are found on non-articular regions of bone. The bones have three or fewer marks except for a right humerus (Ro20-1902) (Figure 5b) and a left rib (Ro20-2034) (Figure 7c). The first case has nine slight chop marks on the medial aspect of the diaphysis, and the second has five chop marks, on the superior and inferior border. The humerus could represent a case of overkill (Jiménez-Brobeil et al., 2014; Kimmerle & Baraybar, 2008; Nikolić & Živković, 2015; Tumler et al., 2019), or an attempt to bisect the humerus. In addition, all the marks are subparallel and with a proximal or inferosuperior orientation, so that every chop was made upwards in the standard anatomical position. The rib may have received several stab wounds from the side of the individual (Jiménez-Brobeil et al., 2014; Kaliszan, 2011; Schmidt & Pollak, 2006; Tumler et al., 2019; Zeppilli et al., 2023), causing considerable damage to internal organs. Both cases represent repeated actions not related to disarticulation or defleshing of the remains but were to cause serious injury.

In the archeological record, chop marks and percussion marks have also been documented in the center of the diaphysis of long bones associated with butchery processes in cases of cannibalism, where the objective is to split the bone in half to access the bone marrow (Novak & Kollmann, 2000). The chop marks documented among the humeri, femora, and tibiae from Roc de les Orenetes are the result of the cutting edge of the object penetrating the soft tissues and impacting the bone, without any seeming intention beyond causing harm to the individual.

5.3 | Different trauma, different weapons

Although the pattern of injuries is similar in all cases (i.e., sharp force trauma in the form of chop and slice marks), it is possible to differentiate the action of different weapons. Most of the sharp force trauma has morphological characteristics that indicate the use of copper or bronze metal objects, which is consistent with the chronology of the site. Multiple experimental studies have been carried out with both archeological and forensic interest to identify the fracture patterns associated with the use of heavy cutting metal weapons on long bones (Brinker et al., 2016; Greenfield, 1999, 2013; Lewis, 2008; Lynn & Fairgrieve, 2009; Okaluk & Greenfield, 2022; Strong & Fibiger, 2023; Walker & Long, 1977). The chop marks produced by metal weapons are characterized by clean cuts with a V-shaped cross-section, smooth walls, with the lifting of a bone flake following the direction of the blow, and without great damage or fracturing of the surrounding bone tissue (SI, Figure S5). These SFT have been widely documented in the archeological record to permit comparison with those found in the osteological assemblage from Roc de les Orenetes (Brinker et al., 2016; Cohen et al., 2015; Dittmar et al., 2019; Fernández-Crespo et al., 2020; Forsom et al., 2017; Jiménez-Brobeil et al., 2014; Jordana et al., 2009; Nicklisch et al., 2022; Tumler et al., 2019; Valoriani et al., 2017; Zeppilli et al., 2023).

In some cases, such as humerus Ro21-3469 (Figure 4c) or radius Ro20-1960 (Figure 6a), the cutting edge of the object did not penetrate the diaphysis but sliced off a small fragment of cortical bone. Such evidence is consistent with a cut occurring at a very oblique angle to the bone (Šlaus et al., 2010; Tumler et al., 2019), and although it is not possible to see the V-shaped profile, the cut surface is so smooth that it is possible to infer with high confidence that such clean cuts caused by metal. In contrast, chop marks caused by stone objects, such as polished axes, are usually characterized by greater destruction of surrounding cortical bone, a wider V-profile, and the walls of the cut are not smooth and polished, but irregular and with associated striations (Chenal et al., 2015; Mariotti et al., 2020; Okaluk & Greenfield, 2022).

Therefore, according to the pattern of injuries and comparison with other archeological cases, we can interpret that the weapons associated with sharp and clean chop marks on long bones documented at Roc de les Orenetes were metal sharp-blunt objects, such as copper and bronze axes or daggers (SI, Figure S6). These objects are known from these periods in the northeast of the Iberian Peninsula around 4500–4000 years cal. BP, with multiple archeological parallels elsewhere (SI, Figure S7), such as the beginning of copper metallurgy in the Chalcolithic (Kunst, 2013; Montero-Ruiz et al., 2021; Oms et al., 2016; Roberts et al., 2009; Soriano, 2013), as well as the manufacture of the first bronze weapons and tools at the beginning of the Early Bronze Age (Barril, 1982; Fernández-Miranda et al., 1995; Martín, 2003; Rovira, 2006; Soriano, 2013). This is the first time that the use of metal objects has been associated with interpersonal violence in this region.

The differentiation between copper and bronze through chop marks is not always possible. Axes of these metals share many characteristics and there are not many specific experimental studies on this. However, Okaluk and Greenfield (2022) showed that copper has much more difficulty than bronze in penetrating deep into dense bone, and even cutting completely through a diaphysis. In addition, copper generates more crushing and irregularity at the point of

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impact, while bronze can produce clean cuts without causing much damage to the bone surface around the chop mark. Therefore, it is likely that some clean chop marks, such as the deep chop present on humerus Ro21-3375 (Figure 5a), the oblique chop marks on humerus Ro21-3469 (Figure 4c) and radius Ro20-1960 (Figure 6a), and the complete transverse cut of radius Ro21-3453 (Figure 6d, SI Figure S6b), were made with bronze axes.

The chop marks observed on the upper and lower edges of ribs (Figure 7) also have characteristics associated with metal objects. They are not high-energy impacts like those observed on the long bones, but wide incisions consistent with stabbing using a sharp metal object such as a dagger (Fernández-Miranda et al., 1995; Martín, 2003; Rovira, 2006; Harding et al., 2007, p. 110; Soriano, 2013). Such injuries are widely documented in both the archeological record (Harding et al., 2007, p. 110; Jordana et al., 2009; Brinker et al., 2016; Tumler et al., 2019) and in forensic and experimental studies (Baiker-Sørensen & Herlaar, 2022; Ferllini, 2012; Kaliszan, 2011; Norman et al., 2018; Schmidt & Pollak, 2006). Rib Ro73-6677/6595 (Figure 7b) represents an interesting case since it is possible to see two contiguous cut marks, separated by 1.2 mm. Observation of these wounds by a topographic scan of the bone surface with confocal microscopy, made it possible to clearly differentiate the entrance and exit wounds related to the entry and extraction of the stabbing weapon (Figure 15b). Moreover, both the cross-sections of these marks and the third SFT on the same bone showed typical characteristics produced by metal blades, with clean and deep cuts (Figure 15a) involving a smooth, flat, and polished incised surface (Figure 15c,d).

Slice marks on ribs also occur in violent confrontations using sharp objects such as daggers when the stab does not penetrate between two ribs but causes a transverse cut on the external rib surface, such as the case on rib Ro73-6442 (Figure 9d, SI Figure S8a) (Brinker et al., 2016; Jiménez-Brobeil et al., 2014; Kimmerle & Baraybar, 2008, p. 270). Experimental studies have shown that this type of chop mark on the upper and lower edges of the ribs correlate to the impact of lithic projectiles (Duches et al., 2016; O'Driscoll & Thompson, 2014). This could be the case of some of the lesions of wider and irregular cross-section, such as ribs Ro21-3324 (Figure 7a) and Ro21-3246 (Figure 7d), although it is not possible to rule out the possibility of a stab wound with a blunter edged weapon.

Regarding the slice marks, some of them display features that allow them to be associated with the use of metal weapons exemplified by scapula Ro73-6873 (Figures 9a and SI Figure S4), and rib Ro73-6442 (Figures 9d and SI Figure S8a). Metal edges are characterized by uniform and clean slices, with V- or |_|-shaped grooves (whether the edge is sharper or duller, the latter being common after continued use of the metal object) without lateral striations, smooth and even polished walls, and very few and narrow internal micro-striations (Figures 16a, SI Figures S4 and S8a) (Alunni-Perret et al., 2005; Greenfield, 2013; Greenfield & Marciniak, 2019, 2021; Kooi & Fairgrieve, 2013; Norman et al., 2018; Smith, 2017, p. 114). In contrast, slice marks caused by stone tools or weapons present a V-shaped cross-section, but are less narrow and sharp, asymmetrical in profile, and feature parallel and internal striations (Figure 16b and SI, Figures S3, S8b, and S9) (Bello et al., 2009; Bello & Soligo, 2008; de Juana et al., 2010; Domínguez-Rodrigo et al., 2009; Greenfield, 2013; Greenfield & Marciniak, 2019, 2021; Hurlbut, 2000).

Some experimental studies have been specifically oriented to differentiate between slice marks produced by bronze and stone weapons or tools (Christidou, 2008; Greenfield, 1999, 2006, 2013; Walker & Long, 1977). Direct comparison with those experiments allows us to relate the previously mentioned cases from Roc de les Orenetes with the use of metal objects, probably daggers made of copper or bronze. However, the longitudinal slice mark on the humerus Ro73-6325 (Figure 9c, SI Figure S9), the rib Ro73-6520 (Figure 9f), and the slice mark on the rib Ro20-1762 (Figures 9b and 16b) have characteristics associated with the use of a stone edged object, with parallel and internal striations and an irregularity of their margins. The case of the rib is particularly interesting since the cut mark is on the internal surface, so the object would have penetrated the soft tissues by passing through the ribs from the side and causing this internal slice mark. Similar cases in the archeological record are linked to the use of long-bladed weapons (Tumler et al., 2019, p. 49), but here, since it is a slice made with a stone edged object, it is most likely related to the use of a lithic knife or blade (Gibaja et al., 2004; Oms et al., 2016; Palomo et al., 2012; Vaquer, 2012), or the impact of a lithic arrowhead (SI, Figure S10).

Bone injuries associated with the impact of lithic projectiles are widely documented in the archeological record from the Paleolithic to the Bronze Age (Alt et al., 2020; Bocquentin & Bar-Yosef, 2004; Crevecoeur et al., 2021; Erdal, 2012; Etxeberria & Vegas, 1992; Flohr et al., 2015; Guilaine & Zammit, 2005; Márquez et al., 2009; Mirazón-Lahr et al., 2016; Roksandic et al., 2006; Smith, 2017; Soriano et al., 2015; Vegas et al., 2012). The marks they cause are both chop marks and slice marks, depending on the angle of impact and the bone affected, frequently affecting the ribs and vertebrae when the shots are directed at the torso, and sometimes remaining embedded in bone (Brinker et al., 2016; Guilaine & Zammit, 2005; Mercadal & Agustí, 2006; Meyer et al., 2009; Smith et al., 2007; Vegas et al., 2012).

Four chert and one bone barbed and tanged arrowheads were documented at Roc de les Orenetes (Figure 12). The pattern of injuries documented in the osteological assemblage, some of them showing features of having been produced by stone sharp edged weapons, and the multimethod analysis of the three arrowheads that underwent functional analysis, allows us to establish a clear use of these arrowheads as projectiles. These weapons, therefore, probably arrived at the site still inside the bodies of the individuals, making it possible to rule out their use as grave goods, as has been proposed by some colleagues for other nearby sites (Gibaja & Palomo, 2003; Palomo, 2002; Soriano et al., 2015). In this case, the analysis revealed a long and intense use life of at least the chert projectiles. Two of the chert arrowheads were used on more than one occasion probably without repositioning the projectile on the shaft (Ro21-2840, Figure 13a–e). They would have been shot repeatedly until they were likely

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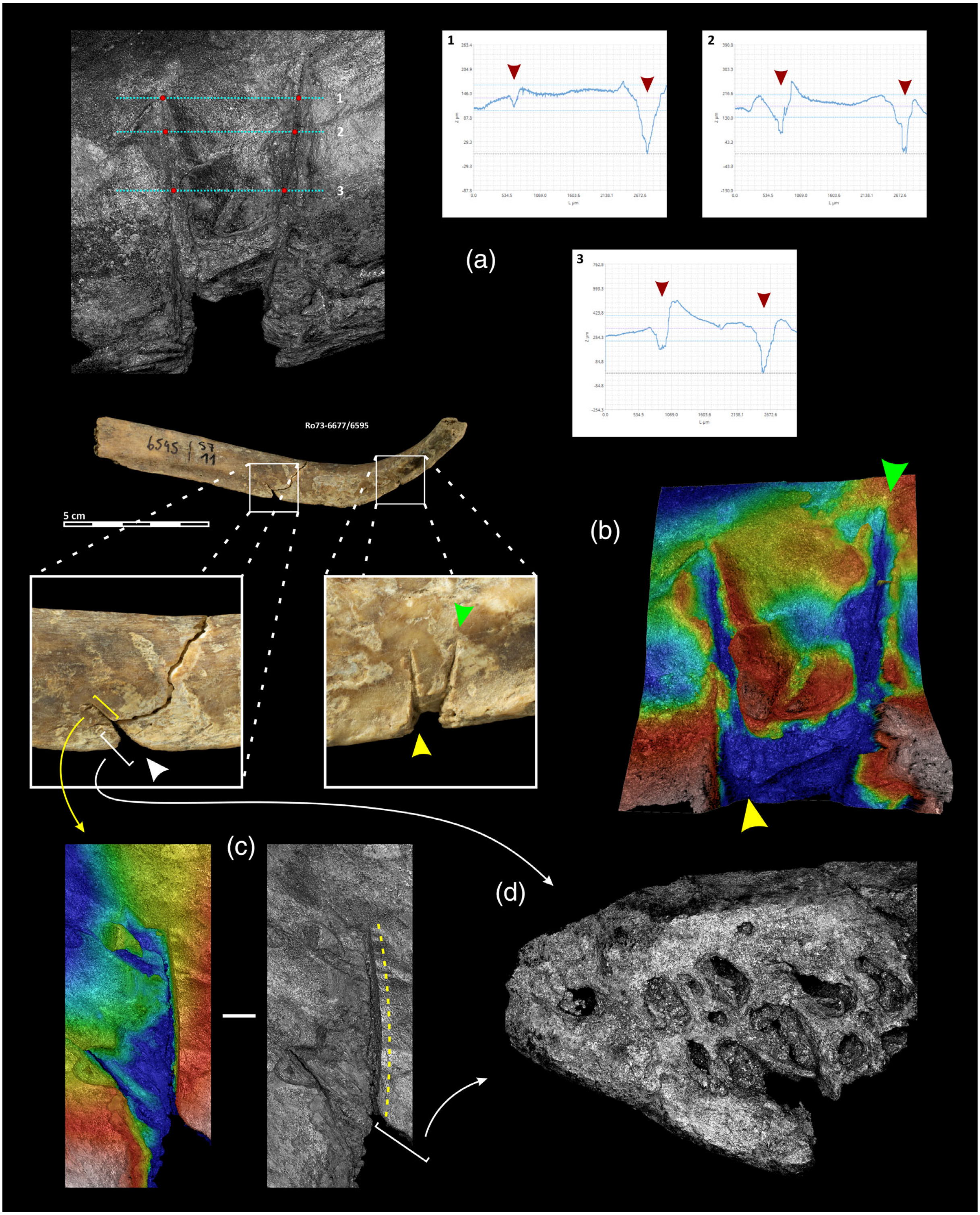

FIGURE 15 Rib Ro73-6677/6595 showing three SFT. The cross-sections made on the internal surface of the rib (a) show a very pronounced V-shaped section of the cut marks. In both these profiles and in the false-color topographic image obtained by confocal microscopy (b), it is possible to observe lifting of the cortical tissue at the entry wound (yellow arrow) and a depression of the cortical tissue surrounding the exit wound (green arrow). The third SFT (c) shows a completely flat and smooth side, with a delaminated opposite wall, generating a slight peeling on the internal surface of the rib, which indicates that it is an entrance wound. The completely transected rib fragment (d) shows a smooth and polished surface due to the metal object used.

embedded in a human body. This is not remarkable, and there are examples of the same piece being shot up to five times without fracturing (Palomo, 2002). In other cases, the reuse led to a total reconfiguration of the morphology (and typology) of the piece (Ro20-1718, Figure 13f,g), permitting it to be used for other activities such as perforating. This type of evidence of change of function in

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pointed elements, and more specifically in tanged and barbed arrowheads, has been described ethnographically (Palomo, 2002), and archeologically to include perforating activities (Gassin, 1996).

According to the pattern of injuries documented, and the comparison with other similar archeological assemblages, more than one type of weapon was used to cause the perimortem injuries, to include copper and/or bronze axes and daggers, lithic projectiles, represented by the arrowheads found at the site, with clear traces of having made impact; blunt objects, such as the one that caused the cranial BFT, and likely lithic blades or knives.

5.4 | Massacre or intergroup confrontation?

The documented wounds were inflicted from anterior and posterior direction (Figure 14). This shows that there is no systematic pattern regarding the type of lesions. In cases of executions, repetitive patterns of injuries are common, especially involving the cranium (Janković et al., 2021; Konopka et al., 2016; Meyer et al., 2015, 2018; Ta'ala et al., 2006; Velasco-Vázquez & Esparza Arroyo, 2016). The injuries observed are also inconsistent with those sustained in a massacre or ambush, where injuries received from the back predominate (Alt et al., 2020; Erdal, 2012; Janković et al., 2021; Madden et al., 2018; Meyer et al., 2009; Wahl & Trautmann, 2012). The skeletal injuries of individuals from Roc de les Orenetes indicate that they took an active part in dynamic interpersonal confrontations, receiving attacks from different directions. Particularly noteworthy are the chop marks on the medial aspect of upper limb bones, suggestive of individuals with their limbs raised, for instance, as attacking at the same time as they received the blows. The case of perimortem amputation represented by the right radius Ro21-3453 can also fall within such a scenario.

The latter case could represent a case of trophy-taking in which the hand of the individual was amputated as a war trophy which is widely documented in the archeological and ethnographic record (Andrushko et al., 2005, 2010; Chacon & Dye, 2007; Chenal et al., 2015; Cohen et al., 2015; Fernández-Crespo et al., 2020; Hurlbut, 2000; Jurmain et al., 2009; Smith, 2017). Additional violent motivations such as an act of disrespect or humiliation towards the victim cannot be ruled out (Andrushko et al., 2005, 2010; Chacon & Dye, 2007; Chenal et al., 2015; Cohen et al., 2015). In addition, the perimortem case of the radius and the antemortem case of the ulna share the same pattern of amputation location, so both could be related to a similar violent act in which the objective was to cut off the hand.

When it has been possible to estimate the sex of the individuals affected by perimortem trauma in complete long bones and cranial bones, they have been in all cases male or probably male. The minimum number of male individuals for the repetition of the same anatomical element is two (left humeri Ro73-4711.1 and Ro73-6325). Many other anatomical elements also show measurements and robusticity that indicate that they are those of males. It is not possible to be completely certain that those bones (cranium, femur, tibia, and radius) belong to different individuals since no anatomical connections were found in the cave. However, they may belong to more than one male, considering both the number of injuries located on different skeletal elements and the time span of the episodes of violence documented. The involvement of multiple males is a common situation observed in other prehistoric sites with evidence of violence, such as in cases of armed inter-group confrontations where adult males were preferentially engaged (Brinker et al., 2016; Chenal et al., 2015; Dittmar et al., 2019; Fernández-Crespo et al., 2018; Jiménez-Brobeil et al., 2009; Sánchez-Barba et al., 2019; Schulting & Wysocki, 2005; Teschler-Nicola, 2012; Vegas et al., 2012).

Other archeological and ethnographic examples provide more variability and evidence that adult females were also involved in violent events (Bengtson & O'Gorman, 2017; Ferguson, 2021; Khudaverdyan et al., 2022; Linduff & Rubinson, 2008; Martin et al., 2010). At Roc de les Orenetes, there is also at least one subadult individual, between 4 and 7 years old, affected by violence as revealed by traumatic injuries to a radius (Figure 6b) and ulna (Figure 9e). Although they are two disarticulated anatomical elements, both provided the same estimated age range, so it is not possible to rule out the possibility that they belong to a single individual. Evidence of violence against children is not unknown during prehistory (Fibiger, 2014; Lewis, 2014; Meyer et al., 2009; Osterholtz & Martin, 2017; Velasco-Vázquez & Esparza Arroyo, 2016) but attempting to speculate why these cuts occurred on the forearms of this (or these) children is not possible.

5.5 | Interpersonal violence in the Pyrenees: A high-mountain context

Although the type of injuries found at Roc de les Orenetes are very similar to each other, mostly SFT in the upper part of the skeleton, it is not possible to attribute them to a single event of inter-group violence in which multiple individuals took part at the same time. The radiocarbon dates obtained from several of these bones with SFT indicate a span of about 400 years (Figure 2). This time range spans from the Late Chalcolithic (*c.* 4600 years cal. BP) to the beginning of the Early Bronze Age (*c.* 4250 years cal. BP). The most likely explanation is that these skeletal remains correspond to several episodes of lethal violence repeated over time and bodies accumulated successively in the same burial space. The MNI indicates the involvement of at least six individuals during this time frame, but the actual number of people involved could be higher. This would be the case if all skeletal remains with marks of violence belonged to different individuals. It is also important to recognize that most interpersonal attacks do not leave marks on bones but affect only soft tissue (Fibiger et al., 2023; Janković et al., 2021; Judd, 2008; Milner, 2005; Saukko & Knight, 2016). Therefore, the evidence reported here almost certainly represents a minimum estimate of violent encounters.

Several sites of similar date to Roc de les Orenetes are known in the northeast of the Iberian Peninsula and the Pyrenees and pre-Pyrenees, assigned to the Chalcolithic—Early Bronze Age, including

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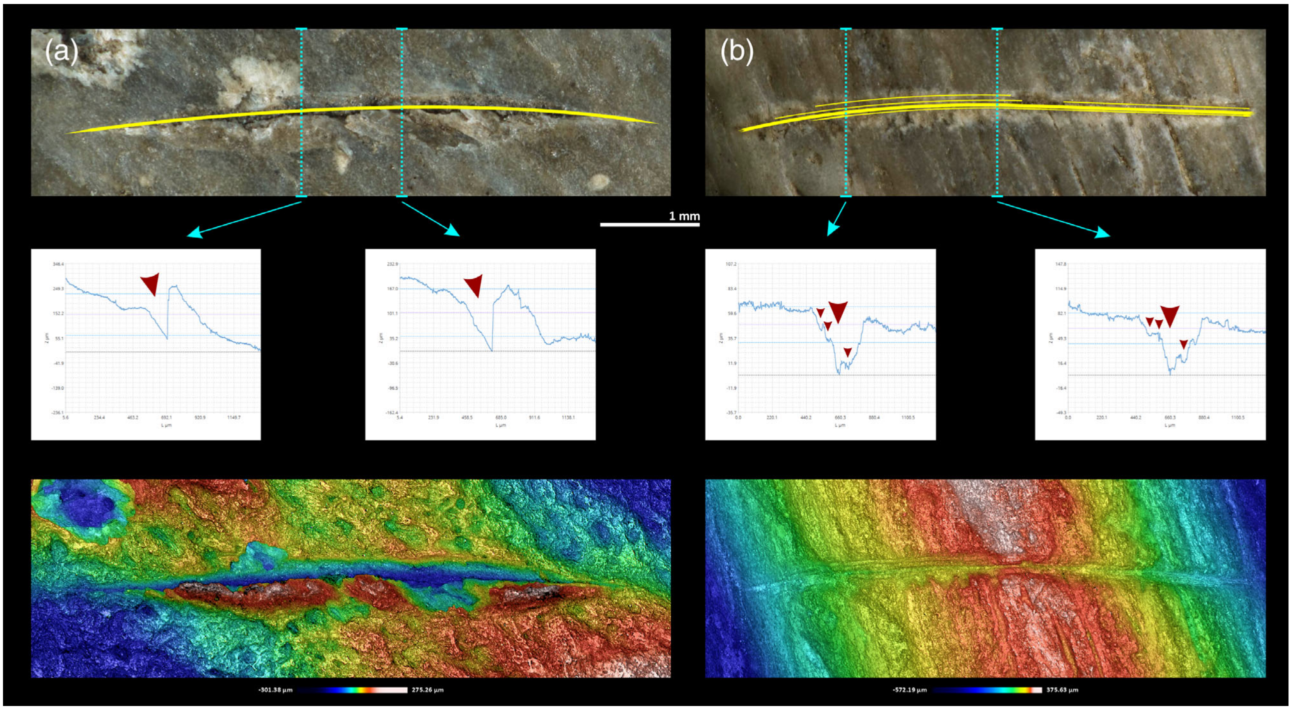

FIGURE 16 Macroscopic and microscopic differences between a slice mark probably made by a metal cutting edge (a), and a slice mark made with a lithic cutting edge (b). Visualization with 3D digital microscope (top), and confocal microscope (bottom), and cross-sections obtained with the confocal microscope at 10x magnification, showing the absence (metal implement) and presence (stone implement) of internal striations on the cut marks. See also these differences in SI Figure S8.

caves occupied for different activities (Laborda et al., 2017; Montes et al., 2016; Oms et al., 2009; Palet et al., 2017; Soriano, 2016; Toledo & Pons, 1982; Villalba-Mouco et al., 2020), and used for funerary practices (Agustí, 1999; Alt et al., 2020; Armentano et al., 2014; Barreres & Huntingford, 1982; González et al., 2011; López et al., 2005; Sánchez et al., 2019; Soriano, 2016; Toledo & Pons, 1982). Armed interpersonal and inter-group confrontations are well known from multiple sites in Europe from both the Chalcolithic (Fabián & Blanco, 2012; Fernández-Crespo, 2017; Janković et al., 2021; Liesau et al., 2014) and Early Bronze Age (Erdal, 2012; Fyllingen, 2003; Jiménez-Brobeil et al., 2014; Needham et al., 2017). Since the Neolithic, interpersonal violence was part of the life in these communities. Current evidence suggests that it was not necessarily a constant atmosphere of violence, but sporadic clashes did materialize between groups (Guilaine & Zammit, 2005; Jiménez-Brobeil et al., 2009; Mercadal & Agustí, 2006; Schulting & Fibiger, 2012; Smith, 2017; Soriano et al., 2015; Wild et al., 2004). What makes the Roc de les Orenetes case unique is the combination of the number of interred individuals, their chronology, evidence of episodic interpersonal violence, and the altitude at which the cave is located, reaching 1836 m.a.s.l.

The most similar case in the northeast of the Iberian Peninsula is the Cova de Montanissell site, located at 1565 m.a.s.l. (Lleida), that contained a minimum of eight individuals (Armentano et al., 2014; López et al., 2005), dating from the Middle Bronze Age. However, there was no evidence of violence. The location and evidence of lethal violence at Roc de les Orenetes draws the closest comparison to the Early Neolithic site of Els Trocs (Huesca). This is a cave located in the Pyrenees, at 1530 m.a.s.l. (Alt et al., 2020), where human remains from a minimum of nine individuals demonstrate perimortem injuries (Alt et al., 2020) consistent with a massacre by another group. The hypogeum of Costa de Can Martorell (Mercadal, 2005; Soriano, 2016) also shows evidence of an inter-group massacre during the Late Chalcolithic, but at 210 m.a.s.l., close to Barcelona. At this site, at least 200 individuals were documented with multiple marks of violence associated with lithic projectiles (Mercadal & Agustí, 2006). Some localities have documented more or less long-lasting periods of sporadic but constant lethal confrontations between individuals, which would be the case at Roc de les Orenetes. The oldest case is represented by the cemetery of Jebel Sahaba (Sudan), dating from the Late Pleistocene, where multiple individuals endured SFT and impacts from lithic projectiles (Crevecoeur et al., 2021).

One of the most representative cases of collective burial with numerous victims of lethal interpersonal violence is San Juan ante Portam Latinam (Northern Spain), where a minimum of 338 individuals from the Late Neolithic were found with abundant cranial BFT and arrowhead wounds (Fernández-Crespo et al., 2023; Vegas et al., 2012). The stratigraphic superimposition of the skeletons, together with radiocarbon dates, indicate the occurrence of more than one violent confrontation over 200–300 years (Fernández-Crespo et al., 2018, 2023), although the possibility of a single large-scale violent event involving most individuals cannot be completely ruled out.

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The site of Velim (Bohemia, Czech Republic) showed evidence of interpersonal violence in some human remains, produced in several episodes during the Early and Middle Bronze Age (Harding, 2007; Harding et al., 2007), and, likewise, the site of Tepe Hissar (Iran) also showed recurrent interpersonal violence over two millennia between the Chalcolithic and the Bronze Age manifested as perimortem BFT and SFT (Afshar et al., 2018). For Roc de les Orenetes we propose a similar scenario following the osteological evidence for both antemortem and perimortem trauma and radiocarbon dates indicating recurrent small-scale conflict among these high mountain human groups at the end of the Chalcolithic and the beginning of the Bronze Age.

6 | CONCLUSION

Roc de les Orenetes was used as a funerary cave between the Late Chalcolithic and Early Bronze Age. A minimum of 51 individuals was found in this collective burial, with all age groups and both sexes represented, but the majority were adult males. Taphonomic analysis indicates that these are primary burials in which complete bodies were deposited in the cave. At least six of these individuals were involved in interpersonal lethal confrontations, as reflected in numerous SFT, and one BFT documented in the skeletal remains. Due to the disarticulated, partially fragmented, and commingled state of the bones, it is possible to estimate that the actual number of individuals exposed to violence was higher. The characteristics, quantity, and skeletal distribution of the cut marks permits association with events of interpersonal violence and not secondary funerary treatment of the bodies.

The type of perimortem trauma indicates intense episodes of violence, with multiple sharp and penetrating trauma, including amputation of the forearm in one case. The pattern of wounds on the remains suggests that they correspond to multiple confrontations between individuals, and not a massacre or execution. The injuries are mostly located in the upper body, especially the upper limbs and ribs, on the anterior, posterior, lateral, and medial aspects. The sharp force blows were made from various directions, although superoinferior was the predominate anatomical orientation. The morphological features of the lesions indicate the use of different weapons and different raw materials. Chop marks have a clean section, with one smooth wall without striations, and peeling on the opposite wall. Comparison with other archeological, forensic, and experimental cases allows us to associate this type of mark with the use of metal axes, in this case, copper or bronze. Some of the slice marks documented are also related to metal objects, probably indicating the use of copper or bronze daggers or knives. Other slice marks indicate the use of stone implements, with more irregular walls and lateral and internal striations, probably related to the use of stone knives or lithic projectiles. In the latter case, four chert arrowheads were found at the site, whose use-wear analysis indicated their use as a projectile. These objects would have arrived at the cave inside the bodies of some of the individuals, and not as grave goods.

Roc de les Orenetes represents a unique site for the study of high mountain human populations during the Chalcolithic—Bronze Age. Firstly, the large number of individuals found, and the good state of preservation permits detailed study of the funerary practices of these communities, as well as the post-depositional taphonomic modifications that their skeletal remains underwent. On the other hand, the evidence of interpersonal violence has made it possible to study the nature of these inter-group confrontations, the severity of the injuries, the demographic profile of the individuals involved, and the type of weapons used. This evidence represents recurrent violent behavior and evidence of interpersonal violence located at the highest altitude of the Pyrenees is likely a reflection of an atmosphere of dynamic and contested socioeconomic relationships during this period in Western Europe where frequent small-scale conflicts materialized even in the most rugged geographical conditions.

AUTHOR CONTRIBUTIONS

Miguel Ángel Moreno-Ibáñez: Conceptualization (lead); formal analysis (lead); investigation (lead); methodology (lead); writing – original draft (lead). **Palmira Saladié:** Conceptualization (equal); investigation (supporting); methodology (equal); supervision (lead); writing – review and editing (lead). **Iván Ramírez-Pedraza:** Writing – review and editing (supporting). **Celia Díez-Canseco:** Writing – review and editing (supporting). **Juan Luis Fernández-Marchena:** Investigation (supporting); methodology (supporting); writing – review and editing (supporting). **Eni Soriano:** Writing – review and editing (supporting). **Eudald Carbonell:** Funding acquisition (lead); writing – review and editing (supporting). **Carlos Tornero:** Funding acquisition (lead); project administration (lead); writing – review and editing (supporting).

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OPEN RESEARCH BADGES

This article has earned an Open Data badge for making publicly available the digitally-shareable data necessary to reproduce the reported results. The data is available at [https://doi.org/10.5281/zenodo.7838035].

DATA AVAILABILITY STATEMENT

All materials generated and used in this study (documentation of cut marks with confocal microscopy) are available in the "Supporting Information file", and in Zenodo Open Access Repository (https://doi.org/10.5281/zenodo.7838035).

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