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Troubles in Tuva: Patterns of perimortem trauma in a nomadic community from Southern Siberia (second to fourth c. CE)

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Abstract

Objectives: Warfare is assumed to be one of the defining cultural characteristics of steppe nomads in Eastern Eurasia. For the first-centuries CE, a period of political turmoil in Northern China and Southern Siberia, relatively few data are, however, available about the degree and variability of violence in these communities. Here, we provide new data on violence among steppe nomads during the first-centuries CE by analyzing the type, anatomical distribution, and demographic distribution of perimortem trauma at Tunnug1 (Tuva, Southern Siberia—second to fourth c. CE).

Materials and Methods: Perimortem traumas were assessed on 87 individuals representing both sexes and different age classes. The timing of the lesions was assessed based on morphological criteria, including the absence and presence of bone reactive processes and the relative plasticity of the bone at the moment of impact. The distribution by age, sex, and anatomical location of trauma was analyzed by means of logistic models, Fisher's exact tests, and 3D visualizations.

Results: A total of 130 perimortem traumas, including chop marks, slice marks, penetrating lesions, and blunt traumas were identified on 22 individuals. Chop marks were mostly at the level of the skull and vertebrae and were likely caused by bladed weapons. Slice marks were found on the cervical vertebrae and cranium and may be the result of throat slitting and scalping by means of smaller bladed implements. Traumas were more frequent in males, and their presence is not correlated with age.

Discussion: This study adds new data to the few available regarding violence among steppe nomadic cultures and provides new insights about the effects of political instability on the life of the people inhabiting Eastern Eurasia during the early centuries CE.

KEYWORDS

anatomical region, decapitation, throat slitting, Kokel, scalping, skeletal lesion, Tunnug, Xiongnu

1 | INTRODUCTION

1.1 | Historical and archaeological background

Since the emergence of nomadic pastoralism in Eastern Eurasia, warfare became a cultural characteristic of steppe nomads. Greco-Roman and Chinese historiography is often focused on the military prowess and peculiar lifestyle of these "barbarian" cultures, perceived as a permanent menace to the borders of sedentary states (Annibaletto, 2007; Ricci, 2015; Watson, 1993). The reliability of these depictions is, however, problematic, given their origin from second-hand observations and generalizations and being often affected by political biases. In this scenario, bioarchaeology appears particularly suited when trying to reconstruct a more nuanced portrait of the lifestyle of these societies. In particular, the analysis of skeletal traumas, by focusing on excavated human remains, offers a unique perspective to study violence in the past. These traumas may indeed provide information about the type and degree of violence experienced by a population. Further the type of weaponry used, the demographic groups more prone to be exposed to interpersonal aggression, and, in some cases, the social context of violent interactions (e.g., raids, organized warfare, ritual killings) can be evaluated (e.g., Jiménez-Brobeil, Roca, Laffranchi, Nájera, & Molina, 2014; Meyer, Lohr, Gronenborn, & Alt, 2015; Nicklisch, Ramsthaler, Meller, Friederich, & Alt, 2017).

Anthropological and bioarchaeological studies of skeletal remains from Central Asia are relatively scarce and include analyses of Bronze Age, Iron Age, and, to a lesser extent, younger contexts (Blau & Yagodin, 2015; Clisson et al., 2002; Crubezy, Magnaval, Francfort, Ludes, & Larrouy, 2006; Jordana et al., 2007; Joseph, 2016; E. M. Murphy, 2003a, 2003b; E. M. Murphy, Donnelly, & Rose, 1998; E. Murphy, Gokhman, Chistov, & Barkova, 2002; Ricaut, Keyser-Tracqui, Cammaert, Crubezy, & Ludes, 2004; Wentz & de Grummond, 2008). Despite this increasing availability of data, the lifestyle of nomadic and seminomadic pastoralists during the first centuries CE is still comparatively unexplored, a gap in knowledge which is relevant given the role played by these people on the geopolitical and social developments of Western Europe and Eastern Asia (Barfield, 1992; Ricci, 2015). This issue is especially important when trying to understand the type of violence these communities were exposed to. Given the accent posed on warfare by ancient ethno-historiographers depicting steppe nomads (Annibaletto, 2007; Barfield, 1992; Chiesa, 2014; Di Cosmo, 2002; Ricci, 2015), previous studies dealt with patterns of skeletal trauma in Central Asian skeletal samples dating from the last centuries BCE to the early centuries CE (Alekseev & Gokhman, 1970; Eng, 2007; Joseph, 2016; E. M. Murphy, 2003a, 2003b; Tur, Matrenin, & Soenov, 2018). Their results point to the relevant role of violence among these cultures, and its link to political, economic, and cultural factors (Eng, 2007; Joseph, 2016; E. M. Murphy, 2003a; E. Murphy et al., 2002; Tur et al., 2018). Still, the paucity of studies calls for new analyses on additional archaeological contexts in order to further elucidate the cultural, demographic, chronological, and geographic variabilities of violence among the nomadic communities of Central Asia during the early centuries CE.

1.2 | Archaeological context and site study

The Republic of Tuva, situated in the Sayano-Altai Mountains of Southern Siberia, features a rich archaeological record documenting its human occupation since the Paleolithic (Vasil'ev & Semenov, 1993). Among the most significant archaeological findings from the region is a series of princely burial mounds (*kurgans*) of the early "Scythian" period. The latter includes the Arzhan and Aldy-Bel cultural horizon encompassing a period from the late ninth to sixth c. BCE (Caspari, 2020). Excavations of these princely burial mounds have generated archaeological and anthropological data of relevance for the interpretation of the Scythian material culture in Siberia and, in general, Central Asia (Caspari et al., 2019; Caspari, Sadykov, Blochin, & Hajdas, 2018; Gryaznov, 1980, 1984; Parzinger, 2006; Zaitseva et al., 2007). Following the decline of the Scythian material culture, new pastoral nomadic cultures from the East entered Central Asia in concomitance with the expansion of the Xiongnu Empire (Di Cosmo, 2002).

From roughly the second-century BCE until the fifth-century CE, the Scythian period in Southern Siberia and Central Asia is followed by a so-called "Hunno-Sarmatian" period. The latter has been defined variously in Tuva (e.g., *Shurmak* by Kyzlasov (1979); *Syyn-Churek* by Vainshtein and Diakonova (1966); and *Kokel* by Savinov (2003)). It is considered that the "Hunno-Sarmatian" period of Tuva comprises a minimum of two cultural horizons (Sadykov, 2018), of which the Kokel culture (second–fifth-century CE) is mostly represented by funerary contexts, and, in only one case, by a settlement (Sadykov, 2017).

The excavation at Tunnug1 started in 2017, as a joint Russian-Swiss project. The site was identified as one of the earliest "royal" tombs of Scythian material culture in Siberia known to date (Caspari et al., 2018). It is located in the Uyuk Valley in Tuva Republic, which features a continental climate and nowadays a semi-arid environment characterized by a mixture of east Siberian Taiga, Mongolian steppe, and semi-desert elements. In 2019, an extensive geophysical survey revealed the buried peripheral monuments of the Tunnug1 site including a large amorphous stone structure to the South of the main burial mound. The structure, preliminarily assigned to the Kokel period based on typical ceramic shard finds, was mainly built up using stones of the main Scythian burial mound (Caspari et al., 2019). The excavations of this complex revealed 46 burials including both single depositions and burials including more than one individual (Figure 1a–c). The cemeterial area can be attributed to the Kokel cultural horizon based on associated grave goods. Grave goods include Kokel ceramics with characteristic arch decorations, iron knives, arrowheads, and gold items typical of the second to fourth centuries CE (Sadykov, Caspari, & Blochin, 2019).

Published anthropological data suggest that the people inhabiting Tuva during the first–fifth centuries CE experienced significant levels of violence. By analysis of 202 individuals from Aymyrlyg, E. M. Murphy (2003a) noted the presence of sharp force trauma, decapitations, penetrating lesions, as well as skeletal evidence of other treatments (throat slicing, scalping, and extraction of the brain; see also E. M. Murphy, 2003a; E. Murphy et al., 2002). Widespread skeletal traumas

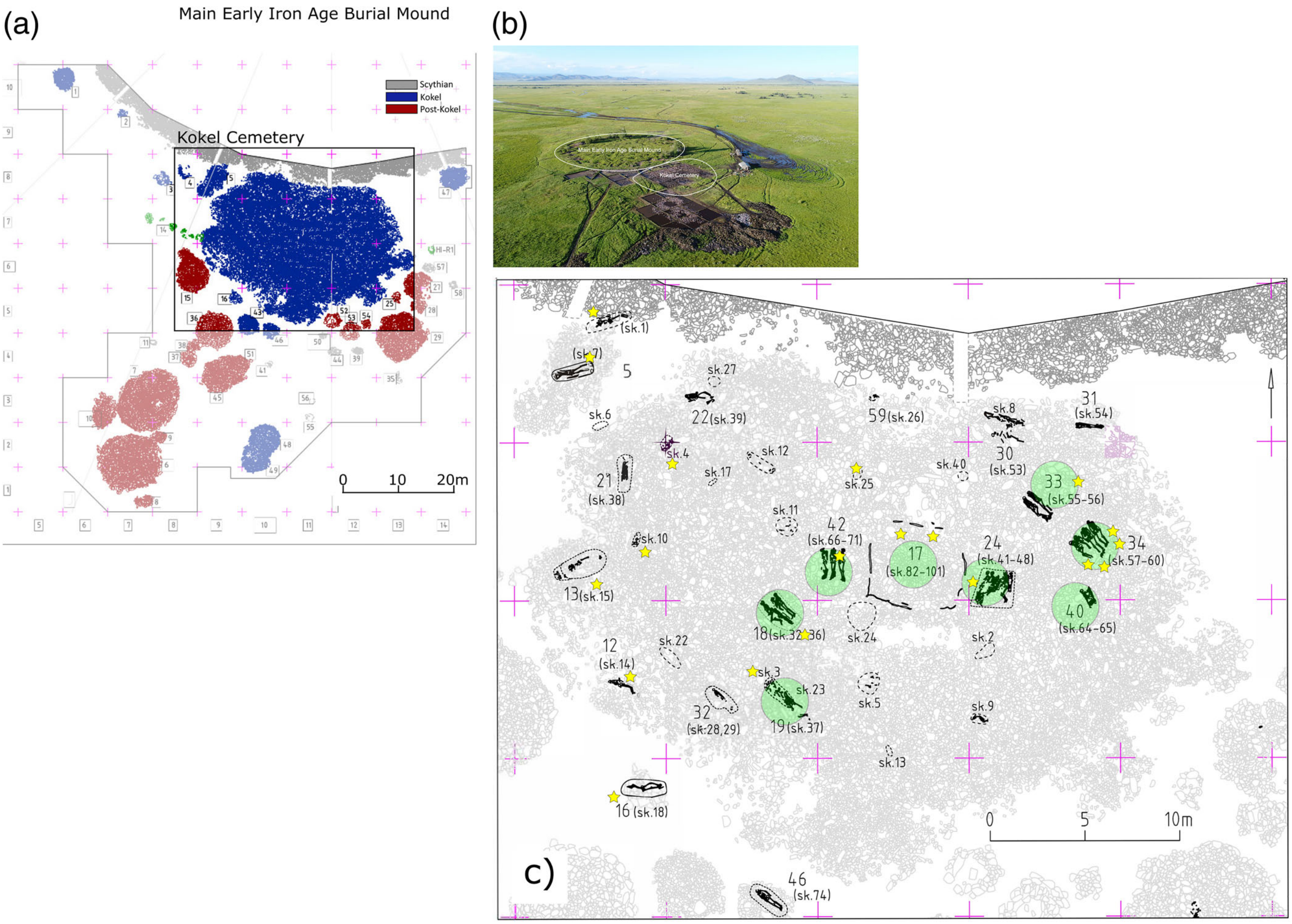

FIGURE 1 Tunnug1: (a) plan of the post-Iron Age funerary area; (b) picture showing the spatial position of the Kokel cemetery relative to the main Early Iron Age burial mound; (c) detail of the Kokel funerary area. Numbers refer to funerary structures; "sk" numbers identify individual skeletons. Green circles highlight funerary structures including individuals with perimortem traumas. Stars indicate funerary structures sampled for ^{14}C dating (see Table 2 for details)

were also found in the necropolis of Kokel (Alekseev & Gokhman, 1970), the eponymous site of the cultural context the individuals in our study stem from. At both Aymyrlyg and Kokel, traumas were found on both sexes and among adults and subadults. These results hint at high levels of indiscriminate violence possibly in the context of intergroup small-scale conflicts (i.e., raids), and, possibly to an active participation of women in warfare (E. M. Murphy, 2003a, p. 98). Violence among these cultures was probably also related to the performance of rituals, as suggested by traces of scalping, decapitation, and excerebration at Aymyrlyg (E. Murphy et al., 2002; E. M. Murphy, 2003a).

Here, we provide an analysis of perimortem trauma among the individuals buried in the peripheral Kokel cemetery of Tunnug1. The aim of our study is to contribute new data regarding the variable contexts of violence among the nomadic cultures of Central Asia during the early centuries CE. In particular, the possible link of violence to warfare, executions, and rituals is tested by addressing two research questions:

1. Which type of lesions and anatomical distribution characterizes perimortem trauma at Tunnug1, and what does this tell about the events leading to such evidence?
2. Which demographic distribution characterizes perimortem trauma, and what does it tell about the exposure to violence among the sexes and age groups of this population?

2 | MATERIAL AND METHODS

2.1 | Sample

The skeletal sample includes all individuals excavated at Tunnug1 between 2018 and 2019 and attributable to the Kokel culture based on radiocarbon data and/or material culture. In total 46 burials were discovered, including single depositions (n = 39) and burials containing more than one individual (n = 7). A detailed plan of the burials is provided in Figure 1c. Burials with more than one individual include funerary

Structures 17 (skeletons 82–101), 18 (skeletons 32–36), 24 (skeletons 41–48), 33 (skeletons 55–56), 34 (skeletons 57–60), 40 (skeletons 64–65), and 42 (skeletons 66–71). All others individuals were buried in individual pits, although in some cases in close proximity to each other. In at least two cases (Structures 33 and 34), even though placed within the same pit, individuals were buried in individual wood coffins.

Individuals are inhumated, mostly in supine and extended position, and buried in simple pits placed under a stone mound within an area of more than 1,000 m^2. Skeletal remains are overall excellently preserved, although in some cases heavily disturbed by environmental causes (freezing and thawing of the soil creating frost-related movements of the substrate). One burial (Structure 17) included the commingled skeletal remains of various individuals, and is the only structure clearly affected by anthropogenic disturbances. This conclusion is based on the high degree of disturbance characterizing the skeletal remains, unlikely to be due solely to environmental processes, and by the lack of traces of animal activity on the bones (e.g., gnawing marks, puncture marks). Grave goods vary quantitatively and qualitatively and include iron knives, arrowheads, buckles, vessels, bridles and pottery, and, in some cases, golden foil jewelry (e.g., earrings, beads, and twisted stripes of gold foil placed between the jaws of individuals).

2.2 | Radiocarbon dating

Radiocarbon dating of collagen samples from 19 individuals was carried out at the LARA laboratory at the Department of Chemistry and Biochemistry at the University of Bern according to Szidat, Vogel, Gubler, and Lösch (2017). For this purpose, bone surfaces were first cleaned by mechanical abrasion and ultrasonication in ultrapure water, and, after drying, ground to 0.5–1 mm using a ball mill (MM 400, Retsch, Haan). An acid–base–acid procedure was then performed at room temperature: 0.5 mol/L hydrochloric acid (HCl) for 60 hr, 0.25 mol/L sodium hydroxide (NaOH) for 1 hr, 0.5 mol/L HCl for 1 hr.

The material was then gelatinized in diluted HCl at pH 3 and 60°C, the warm solution filtered by means of precleaned Ezee-Filters, ultrafiltration was performed with Vivaspin™ 15 30 kDa molecular weight cut-offs (MWCO) ultrafilters (Sartorius) and the high-molecular-weight fraction was lyophilized (Alpha 2–4 LSC, Martin Christ Gefriertrocknungsanlagen GmbH, Osterode am Harz). The extracted collagen was combusted and graphitized using an automated graphitization equipment. ^{14}C measurements were performed with the accelerator mass spectrometry system MICADAS, using ^{14}C-free sodium acetate and the NIST standard oxalic acid II (SRM 4990C) for blank subtraction, standard normalization, and correction for isotope fractionations (Szidat et al., 2014). Radiocarbon ages were translated into calendar ages with OxCal 4.3 (Bronk Ramsey, 2009) using the IntCal13 calibration curve (Reimer et al., 2013).

2.3 | Demographic profile

Subadult age-at-death was estimated based on the development and eruption of deciduous and permanent dentition, diaphyseal measurements, and degrees of epiphyseal fusion (AlQahtani, Hector, & Liversidge, 2010; Maresh, 1970; Moorrees, Fanning, & Hunt, 1963; Ubelaker, 1989; see also Schaefer, Black, & Scheuer, 2009; Scheuer & Black, 2000). Adult age-at-death was estimated based on the morphological changes of the auricular surface of the ilium, symphysis of the pubis, and sternal ends of the ribs (Brooks & Suchey, 1990; Buckberry & Chamberlain, 2002; İşcan, Loth, & Wright, 1984).

For the aim of analysis, individuals were then grouped in age classes: neonates (up to 3 months of age), infants (4 months–3 years), children (3–12 years old), adolescents (13–18 years old), young adults (19–34 years old), middle adults (35–49 years old), and old adults (≥50 years old). Some remains, which consisted mostly of fragmented bones, were grouped in broader age classes: subadults (ca. <19 years old) and adults (ca. >19 years old).

Sex was estimated only for adult individuals based on the dimorphic features of the cranium, mandible and innominate bone (Ascadi & Nemeskeri, 1970; Ferembach, Schwidetzky, & Stloukal, 1980; Phenice, 1969).

In the case of Structure 17, the commingled skeletal elements required a calculation of the minimum number of individuals (MNI). The latter was obtained from counting all identifiable teeth and bilateral bones for each side and keeping the highest number as the MNI (White, 1953). In order to avoid duplications, the calculation of MNI was performed separately on preserved bones (minimum preservation of 80%), as well as on isolated proximal and distal fragments. When possible, we assigned skeletal elements to specific sex and age categories following the aforementioned morphological criteria.

2.4 | Trauma analysis

2.4.1 | Types of trauma

Presence and type of trauma were assessed by analyzing all individuals with the aid of a magnifying glass. Traumas were recorded by type, location, and orientation.

Postmortem breakages were differentiated from both antemortem (occurred during the life course) and perimortem (occurred around the time of death) trauma based on absence of reactive processes of the bone, relative plasticity of the element, and the coloration of the lesion compared with the surrounding bone (Berryman & Haun, 1996; Fibiger, Ahlstrom, Bennike, & Schulting, 2013; Knüsel, 2005; Sauer, 1998). Although antemortem trauma can originate from interpersonal violence, bone remodeling around the lesion may hamper a clear distinction between the result of interpersonal violence and accidental events. For this reason, only perimortem traumas were included in the following analyses.

Skeletal lesions were subdivided in blunt trauma, sharp force trauma, and penetrating lesions (Kimmerle & Baraybar, 2008). Two types of sharp force trauma were defined: *chop marks*, featuring a smooth and a rougher fracture wall, the latter variably associated to bone flaking, a size averaging 26 × 10 mm, and an orthogonal force effect to the bone. *Slice marks* are defined by small cut marks with an

TABLE 1 Distribution of the skeletal remains by sex and age class

a)	Neo		Inf		Child		Ad		YA		MA		OA		A		Sub		Tot	
	n	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total
F	0	0.0	0	0.0	0	0.0	0	0.0	5	5.7	1	1.1	5	5.7	3	3.4	0	0.0	14	15.9
M	0	0.0	0	0.0	0	0.0	0	0.0	9	10.3	9	10.3	5	5.7	1	1.1	0	0.0	24	27.4
NA	4	4.6	7	8.0	18	20.7	3	3.4	2	2.3	0	0.0	0	0.0	7	8.0	8	9.2	49	56.1
Tot	4	4.6	7	8.0	18	20.7	3	3.4	16	18.3	10	11.4	10	11.4	11	12.5	8	9.2		
b)	**Neo**		**Inf**		**Child**		**Ad**		**YA**		**MA**		**OA**		**A**		**Sub**		**Tot**	
	n	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total	*n*	(%) Total
F	0	0	0	0.0	0	0.0	0	0.0	3	4.5	1	1.5	5	7.5	0	0.0	0	0.0	9	13.5
M	0	0	0	0.0	0	0.0	0	0.0	8	11.9	7	10.4	5	7.5	0	0.0	0	0.0	20	29.8
NA	4	6.0	7	10.4	15	22.4	3	4.5	2	3.0	0	0.0	0	0.0	7	10.4	0	0.0	38	50.7
Tot	4	6.0	7	10.4	15	22.4	3	4.5	13	19.4	8	11.9	10	15.0	7	10.4	0	0.0		

Note: Frequencies are presented separately including (a) and excluding (b) Structure 17. Relative frequencies (%) refer to the total sample. See the main text for the age ranges corresponding to each age class.
Abbreviations: A, adults; Ad, adolescents; Child: children; F, females; Inf, infants; M, males; MA, males middle; NA, undetermined sex; Neo, neonates; OA: old adults; Sub, subadults; YA, young adults.

average size of 5 × 0.33 mm, and a sliding force effect to the bone (see also Greenfield, 1999; Lewis, 2008). An attempt to estimate directionality was based on the gross morphological features of each lesion (position and angle; Boylston, 2000).

Trauma frequencies were calculated both by individual (frequency of individuals showing trauma by the total number of individuals) and by anatomical region (number of individuals presenting trauma on a specific anatomical region vs. the number of individuals for which that anatomical region is observable). In order to better link the observed traumas to the main areas of the body attacked, we adopted with minor modification the system of Geber (2015). Specifically, we defined the anatomical regions used in this study according to the anatomical regions of the body (and not of the skeleton) (see Geber, 2015, table 1; see also Novak, 2000, table 8.3) (Table S1). Trauma was recorded as a binary variable. Accordingly, if one individual presented one or more traumas on one anatomical region it was recorded as "presence." Only bones presenting at least 50% of preservation were considered as observable.

2.4.2 | Anatomical distribution of traumas

The anatomical distribution of traumas was analyzed by calculating their frequencies for each anatomical region. Differences between regions in the frequency of trauma were tested by means of a Fisher's exact test. A Fisher's exact test was also used to compare frequencies of trauma between sides for each anatomical region. For this purpose, for regions presenting at least one perimortem trauma at the level of the mid axis, we added a "middle" variable besides the customary "left" and "right." The analysis of trauma by anatomical region and side included only articulated skeletons (i.e., without Structure 17).

We complemented these analyses by a 3D representation of trauma frequencies by anatomical region. Each lesion was first marked on a virtual skeleton represented by a triangular surface mesh. Frequencies of lesions were then calculated and weighted using a Gaussian kernel, and visualized on the virtual skeleton by mean of a color heatmap (from white: absence, to red: maximum frequency; see Data S1 for details).

2.4.3 | Demographic patterns of traumas

The distribution of perimortem traumas by age and sex was investigated by means of a logistic model with sex and age class as factors and presence of trauma as a binary dependent variable. Significant results were further investigated by means of post hoc Fisher's exact test. We performed this analysis first considering all evidence of trauma, and separately for each type of trauma.

All statistical analyses were performed in R 3.6.2 (R Core Team, 2019) setting alpha at 0.05 as significance level for all tests. The marking of trauma on the virtual skeleton was accomplished using MorphoDig 1.5.3. (Lebrun, 2018). The 3D rendering of trauma was performed in R using the packages Morpho, and Rvcg

(Schlager, 2017). Analyses of the type and demographic patterns of trauma were based on all the available trauma evidences and included all identified individuals. Analysis by anatomical region and side included only articulated individuals (i.e., the commingled remains from Structure 17 were excluded).

3 | RESULTS

3.1 | Demography and radiocarbon dating

Articulated skeletons from the Kokel cemetery at Tunnug1 amount to 67 individuals. The MNI for Structure 17 (n = 20) was obtained from the number of preserved (>80%) left humeral shafts. The total number of individuals amounts therefore to a minimum estimate of 87 individuals. Table 1 shows the distribution of this sample by sex and age-at-death. Radiocarbon date estimates (Table 2) are largely consistent with those based on the typology of the material culture from the site, pointing to a dating between the second and fourth centuries CE. Only in one case (Skeleton 18 in Structure 16) the dating appears to be later (cal 358–534 CE).

3.2 | Types of trauma

The sample includes a total of 142 lesions (Table S2). Individuals with trauma are 27 (including 23 articulated skeletons and at least 4 individuals from Structure 17 identified on the basis of gross morphological features), amounting to 31% of the sample. The number of injuries per individual range from 0 to a maximum of 12 (average = 1.7). Seven skeletons present antemortem lesions (total number of lesions = 12), all featuring the almost complete remodeling of the bone, and likely caused by traumatic events long predating the death of the individual (Lovell, 1997).

Perimortem trauma are present on 22 individuals, for a total of 130 lesions (Table 3a,b). All perimortem lesions appear violence related, and include chop marks, slice marks, blunt traumas, and penetrating lesions. Chop marks (Figure 2) and slice marks (Figure 3) are the most frequent types of trauma (88 lesions among 22 individuals). Chop marks in some instances partially or completely separated the bone as expected by the use of relatively large bladed weapons wielded with high force (cf. Lewis, 2008; Novak, 2000). If single-counting lesions clearly associated to each other (e.g., lesions on adjacent bones likely resulting from a single blow) the number of chop marks per individual ranges from a minimum of 1 to a maximum of 4 (average = 2.5). Slice marks, represented by 35 lesions (8 individuals), are mostly represented by multiple, subparallel lesions on the same or adjacent bones, and on an individual level are always accompanied by the presence of chop marks, on the same bone or other parts of the skeleton.

The rest of perimortem injuries includes one blunt trauma (on a left humeral shaft) and six penetrating lesions (Figure 4) with different profiles. Two diamond-shaped penetrating lesions with an average maximum and minimum width of 8.5 and 7.2 mm were found on the

TABLE 2 Uncalibrated and calibrated radiocarbon dates from Tunnug1

Skeleton nr.	Lab code	PT	Funerary structure	^{14}C age (BP)	C%	C:N	Calendar age (2σ)
1	BE-11033.1.1	No	5	1,791 ± 20	43.9	3.1	CE 137–325
3	BE-11034.1.1	No	n.a.	1,773 ± 20	45.5	3.2	CE 176–337
4	BE-11035.1.1	No	n.a.	1,723 ± 20	48.6	3.1	CE 252–385
7	BE-11036.1.1	No	5	1,714 ± 20	45.8	3.1	CE 255–391
10	BE-11037.1.1	No	n.a.	1,753 ± 20	42.6	3.1	CE 234–345
14	BE-11038.1.1	No	12	1,740 ± 20	42.3	3.1	CE 241–380
15	BE-11039.1.1	No	13	1,781 ± 20	48.2	3.1	CE 137–325
18	BE-11040.1.1	No	16	1,628 ± 20	41.7	3.1	CE 358–534
25	BE-12824.1.1	No	n.a.	1,768 ± 20	48.9	3.2	CE 216–339
33	**BE-12822.1.1**	**Yes**	**18**	**1,743 ± 20**	**50.5**	**3.1**	**CE 240–378**
46	**BE-12823.1.1**	**Yes**	**24**	**1,755 ± 20**	**50.2**	**3.1**	**CE 233–343**
55	**BE-12821.1.1**	**Yes**	**33**	**1,726 ± 20**	**50.1**	**3.1**	**CE 252–383**
57	**BE-13065.1.1**	**Yes**	**34**	**1,747 ± 19**	**50.2**	**3.1**	**CE 238–346**
58	**BE-13066.1.1**	**Yes**	**34**	**1,716 ± 19**	**50.2**	**3.1**	**CE 255–389**
59	**BE-13067.1.1**	**Yes**	**34**	**1,765 ± 20**	**43.4**	**3.1**	**CE 223–338**
60	**BE-12826.1.2**	**Yes**	**34**	**1,724 ± 19**	**48.6**	**3.1**	**CE 252–384**
68	**BE-12825.1.1**	**Yes**	**42**	**1,746 ± 20**	**50.5**	**3.1**	**CE 238–377**
94	BE-12827.1.1	No	17	1,787 ± 20	51.2	3.1	CE 140–327
95	BE-12828.1.1	No	17	1,738 ± 20	51.0	3.2	CE 242–380

Note: Individuals with perimortem trauma are highlighted in bold.
Abbreviations: n.a., no funerary structure assigned; PT, presence of perimortem trauma.

left side of two frontal bones (Figure 4e,f). The anterior surface of a proximal right tibia (Figure 4a) showed a triangular penetrating lesion with a size of 13 × 8 mm affected was found. A rectangular lesion with a size of 3 × 1 mm was identified on the infraspinous fossa of a left scapula (Figure 4h,i). Two subtriangular lesions were found on the proximal thirds of a left humerus (Figure 4c) and of a left ulna from two different individuals with a size of 12 × 5 and 8 × 5 mm, respectively (Figure 4b). All individuals with blunt traumas and penetrating lesions present chop marks in other parts of the skeletons.

3.3 | Anatomical distribution

Table S3 and Figure S1 show the frequency of chop marks and slice marks by anatomical region. Additionally, Figure 5 illustrates the distribution of each type of trauma on the skeleton. Videos S1 and S2 further illustrate the spatial density of chop marks and slice marks, respectively.

Chop marks are mostly at the level of the cranium (19.4% of individuals), face (27.3%), neck (34.3%), and back (12.9%), with the causing blows originating from left, right, posterior, and anterior directions, and, in some cases (e.g., chop marks on the top of the cranium), apparently from above (Table S2). The other regions (shoulder, upper arm, lower arm, thorax, abdomen, pelvis, upper and lower leg, foot) present a markedly lower frequency of trauma (in the range of 0–7%). In particular, no perimortem lesion was observed on the hand, foot, and abdomen. This pattern is highlighted by the results of pairwise Fisher's tests. In this case, significant results reflect the higher frequency of injuries on the face and, especially, the neck when compared with the other regions of the body (Table S3).

Chop marks are the only type of trauma showing a statistically significant difference between sides, and only at the level of the neck. In this case, the middle anterior area shows the highest frequency of lesions (28.6% of individuals) when compared with the left (5.7%) and right (2.9%) sides (Table S4; Figure S2).

Slice marks are present almost only on the first four cervical vertebrae. The only exception are Skeleton 42, a young adult male, and Skeleton 68, an old adult male. Skeleton 42 presents nine horizontal slice marks on the cranium (four on the frontal, one on the right and four on the left parietal bone, respectively). Skeleton 68 features a

TABLE 3 (a) Frequencies of individuals with perimortem trauma by age class and sex, and (b) frequency of perimortem lesions between adults and subadults

		Chop marks		Slice marks		Penetrating trauma		Blunt trauma	
(a)	*n*	Presence	%	Presence	%	Presence	%	Presence	%
Neonates	4	0	0.0	0	0.0	0	0.0	0	0.0
Infants	6	0	0.0	0	0.0	0	0.0	0	0.0
Children	16	5	31.3	2	12.5	0	0.0	0	0.0
Adolescents	3	1	33.3	1	33.3	0	0.0	0	0.0
YA (F)	3	0	0.0	0	0.0	0	0.0	0	0.0
YA (M)	8	6	75.0	2	25.0	2	25.0	0	0.0
YA (sex NA)	2	0	0.0	0	0.0	0	0.0	0	0.0
MA (F)	1	0	0.0	0	0.0	0	0.0	0	0.0
MA (M)	7	3	42.9	0	0.0	2	28.6	1	14.3
OA (F)	5	1	20.0	1	20.0	0	0.0	0	0.0
OA (M)	5	2	40.0	1	20.0	1	20.0	0	0.0
Adults (F)	1	1	100.0	0	0.0	0	0.0	0	0.0
Adults (M)	1	1	100.0	0	0.0	0	0.0	0	0.0
Adults (sex NA)	7	0	0.0	0	0.0	0	0.0	0	0.0
Subadults	2	2	100.0	1	50.0	0	0.0	0	0.0

	Chop marks		Slice marks		Penetrating trauma		Blunt trauma		Total perimortem	
(b)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
All sample	88	67.7	35	26.9	6	4.6	1	0.8	130	100.0
Females	9	6.9	0	0.0	1	0.8	0	0.0	10	7.7
Males	55	42.3	16	12.3	5	3.8	1	0.8	77	59.2
Adults (sex Na)	7	5.4	0	0.0	0	0.0	0	0.0	7	5.4
Subadults	17	13.1	19	14.6	0	0.0	0	0.0	36	27.7

Note: See the main text for the age ranges corresponding to each age class.
Abbreviations: A, adults; F, females; M, males; MA, middle adults; OA, old adults; Sub, subadults; YA, young adults.

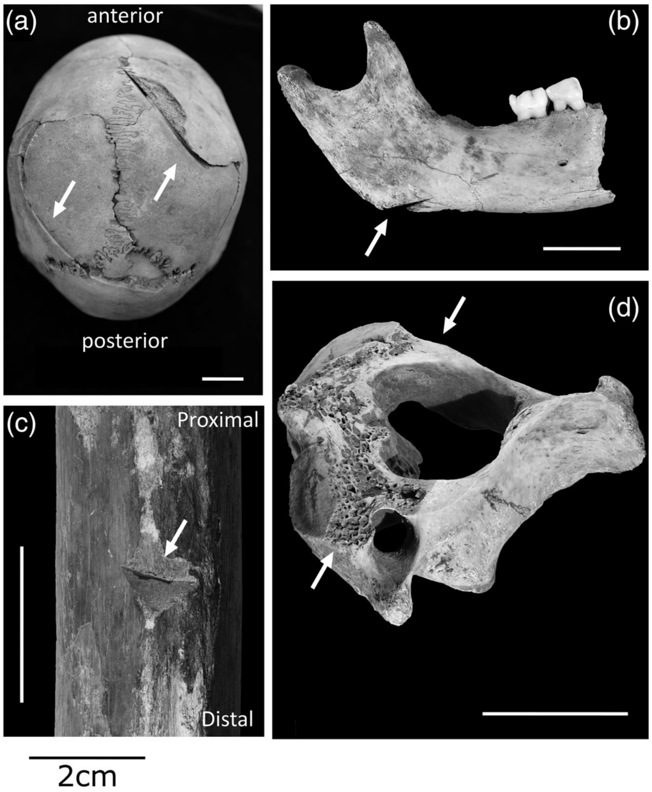

FIGURE 2 Examples of chop marks. The location of each lesion is shown by arrows. (a) Sk66 (young adult male), chop marks on the cranial vault; (b) Sk57 (child): chop mark on the right mandibular angle; 9c) Structure 17, bone fragment 3 (adult, undetermined sex), chop mark on the posterior side of the left femoral diaphysis; (d) Sk42 (young adult male), chop mark on the second cervical vertebra

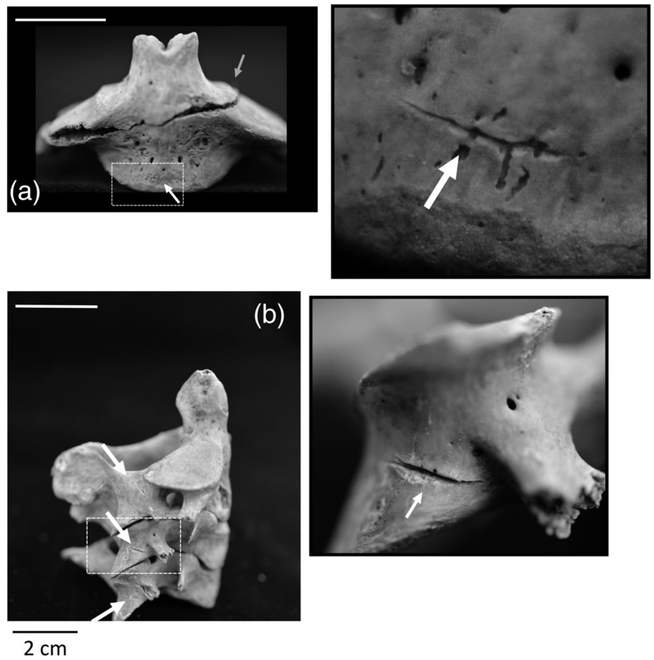

FIGURE 3 Examples of slice marks. The location of each lesion is shown by arrows. (a) *left*: Sk57 (child), slice mark on the anterior side of the second cervical vertebra; *right*: detail of the lesion; (b) *left*: Sk59 (young adult male), slice marks on the left transverse processes of the second, third, and fourth cervical vertebrae; *right*: detail of the lesion on the third cervical vertebra

horizontal slice mark on the posterior side of the left parietal, and an additional one on the left side of the frontal bone.

No significant differences between sides were found for slice marks. As mentioned earlier (Saection 3.2) all individuals with slice marks do also present one or more chop marks. The latter, in these individuals, affect always (but not in all cases exclusively) the cervical vertebrae (see Table S2), the only exception being Skeleton 43, with slice marks on the first cervical vertebrae and one chop mark on the right clavicle.

The extreme rarity of the other types of trauma does not allow for a statistically robust testing of their possible anatomical patterning. However, the upper regions of the body seem the more affected: the single blunt trauma was found on a left humeral shaft, and the six penetrating lesions affect the cranium (two individuals), lower leg, shoulder, upper, and lower arm (one each).

3.4 | Demographic patterns

When considering all types of traumas, the presence of perimortem injuries among adults is significantly associated to sex (higher frequency among males: 12/2:85.7%), but not age (Table 4a). The lack of a significant effect of age on trauma presence is confirmed when running a logistic model using the entire data set (Table 4b), and when comparing the frequency of trauma between subadults (all individuals aged less than ca. 19 years), and adults (individuals aged more than ca. 19 years old) (Table S5). Subadults with trauma include only children and adolescents, with no neonates nor infants showing perimortem lesions (Table 3a). All individuals presenting perimortem trauma show at least one chop mark. The results from the analyses above apply therefore to this specific type of lesion, too. A separated analysis for slice marks reveals no association between presence of lesions and sex or age (Table 4c,d), and no statistically significant difference in the frequency of lesions between adults and subadults (Table S5).

Given their presence in few individuals, we did not attempt a statistical analysis for the demographic distribution of blunt traumas and penetrating lesions. The only blunt trauma was identified on a middle adult male. The six penetrating lesions affect five males (two young adults, one middle adult, and two old adults), and an adult female of undetermined age class.

3.5 | Funerary patterns

Burials including individuals with perimortem traumas tend to occupy the eastern and central part of the cemetery (see circles in Figure 1). Type and quantity of grave goods does not differ between skeletons with perimortem trauma and the other burials from Tunnug1, including ceramics, bone and iron items (Figure S3).

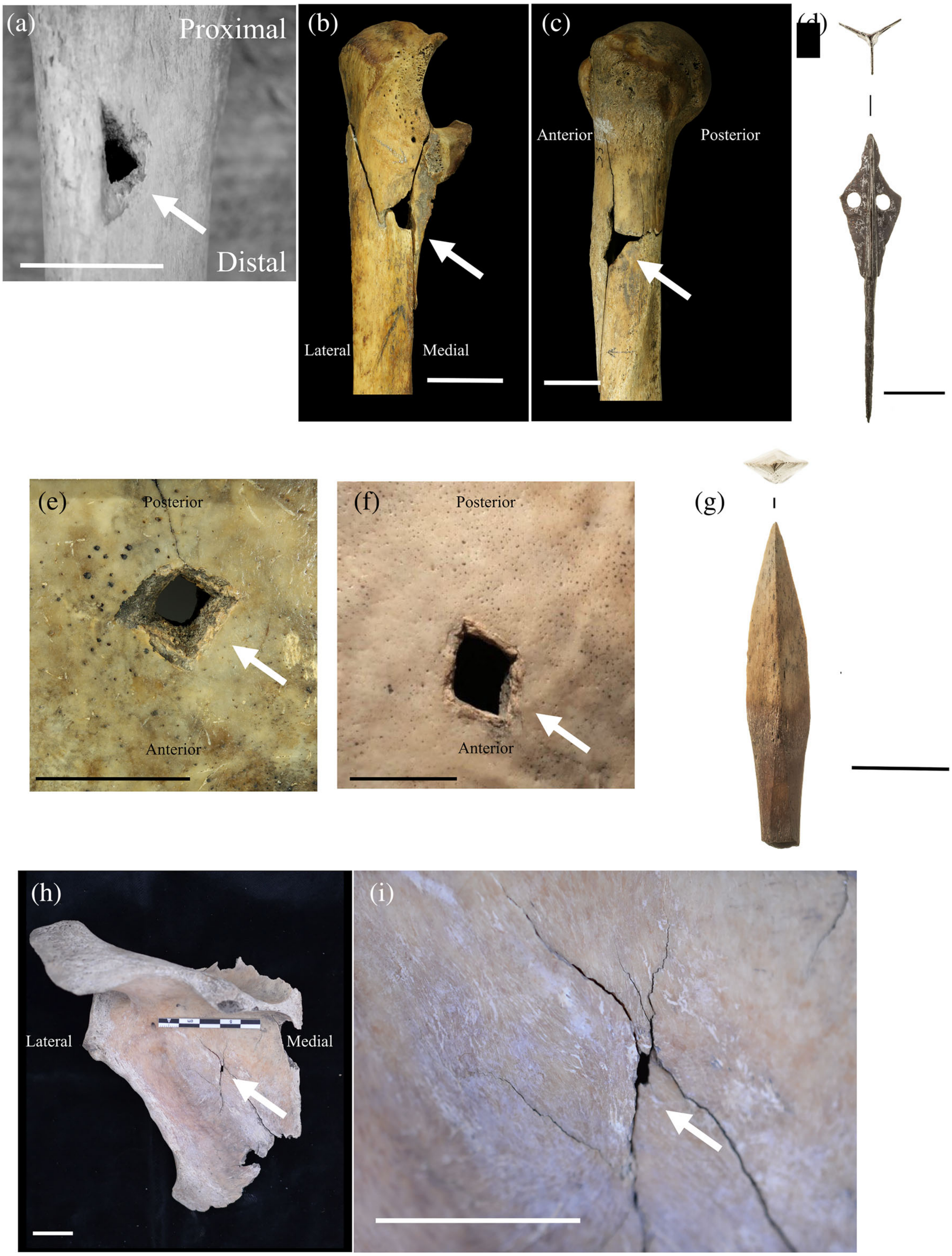

FIGURE 4 Penetrating lesions and arrowheads found at Tunnug1. The location of each lesion is shown by arrows. (a) Sk59 (young adult male), triangular penetrating lesion on anterior surface of right tibial shaft; (b) Sk68 (old adult male), triangular penetrating lesion on left ulna; (c) Sk55 (old adult male), triangular penetrating lesion on left humerus; (d) trilobate iron arrowhead; (e) Structure 17, bone fragment 12 (adult female—age class not estimated): diamond-shaped penetrating lesion on frontal bone; (f) Sk41 (young adult male): diamond-shaped penetrating lesion on frontal bone; (g): rhomboidal bone arrowhead; (h) Sk60 (middle adult male): rectangular penetrating lesion on left scapula; and (i) detail of the lesion. All bars = 2 cm

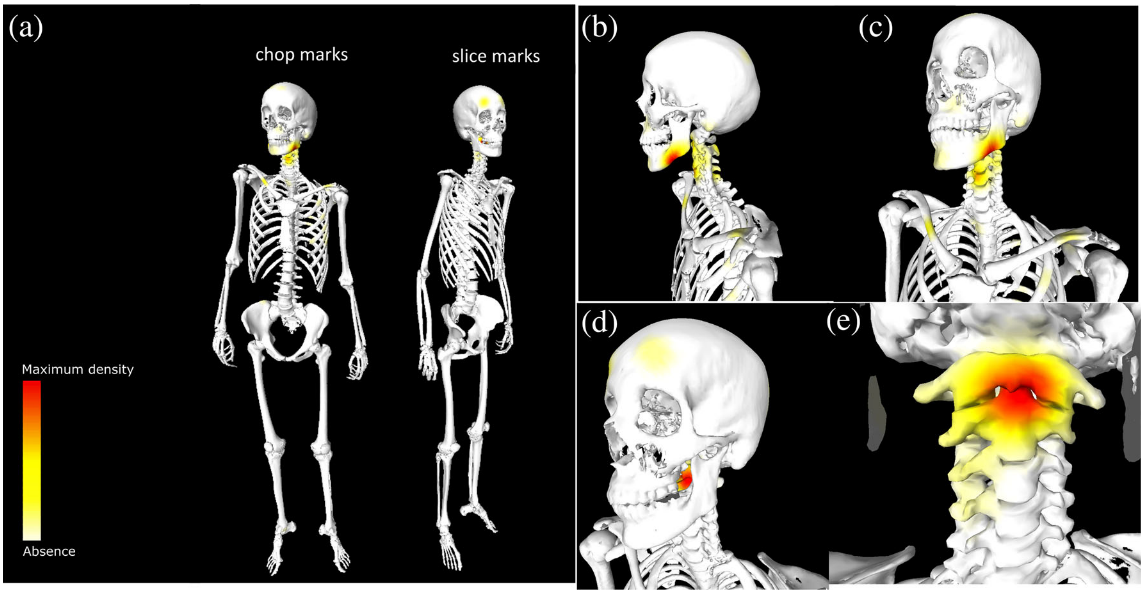

FIGURE 5 (a) 3D model of human skeleton showing the anatomical distribution of chop marks (left) and slice marks (right); (b,c) detail of spatial density of chop marks on the skull, neck, and shoulders; (d,e) detail of spatial density of slice marks on the cranium and upper cervical vertebrae

With one exception (Skeleton 37), perimortem traumas are only found in burials including multiple individuals, with perimortal lesions affecting more than one skeleton (Figure S4).

The environmental disturbance to the skeletal remains hampered the reconstruction of the timing of the depositions in burials with more individuals. A distinction between multiple and collective burials (i.e., simultaneous vs. successive depositions) was therefore not always possible. Nonetheless, simultaneous depositions seem likely in at least three cases (Structures 18, 24, and 40). This is suggested by (a) the lack of disturbance to the skeletal remains—as expected if a new space was obtained from a preexisting burial; (b) the intermingling of articulated skeletons; (c) the delimitation (in Structures 18 and 40) of the burial area by a wooden structure. This hints at the possibility that the burial space was originally prepared for the inclusion of more individuals.

More difficult is the reconstruction of the events leading to Structure 17. Also in this case a wooden structure encloses the burial area, a possible sign that at least part of the individuals may have been buried at the same time. Stratigraphic data do not allow to distinguish if the disturbance to the skeletal remains happened *in antiquo* or during more recent times. An interesting possibility is that Structure 17 may include secondary depositions. However, the presence of skeletal remains in the stone filling of the pit would rather point to a postdepositional disturbance of the remains, possibly resulting from looting activities.

Burials including individuals with perimortem trauma tend to cluster in the eastern and central areas of the cemetery (Figure 1c). Radiocarbon dates estimates of individuals with and without perimortem traumas largely overlap (Table 2).

4 | DISCUSSION

4.1 | Types of trauma

4.1.1 | Chop marks

Chop marks at Tunnug1 are compatible with large-sized bladed objects wielded using a considerable amount of force (cf. Lewis, 2008; Novak, 2000). The same type of lesion has been associated to swords in other South-Siberian contexts dating to the early centuries CE (Alekseev & Gokhman, 1970; E. M. Murphy, 2003a; Tur et al., 2018). Chop marks at Tunnug1 may have been caused by broadswords, backswords or other types of bladed weapons (cf. Khudjakov, 2005). In particular, backsword, relatively short, straight, single-bladed weapons are usually associated to close combat on horseback or when dismounted during hand-to-hand combat (Khudjakov, 1986, p. 79). Swords were not recovered at Tunnug1, but their inclusion in the panoply of steppe nomads is historically and archaeologically documented (Khudjakov, 2005; Ricci, 2015; Watson, 1993). Practical reasons may have led to the absence of these weapons in the burials of Tunnug1, that is, the need to reutilize valued items (Murphy, 2003a).

4.1.2 | Slice marks

The reduced size of slice marks is consistent with their causation by relatively small bladed objects, for example, knives or daggers (Lewis, 2008). Iron knives are largely documented at Tunnug1

TABLE 4 Results of logistic models with total presence of perimortem trauma (a,b) and slice marks (c,d) as dependent variable; (a,c) data set with adults only; (b,d) complete data set including subadults (sex not included as predictor)

	Estimate	*SE*	*z*	*p*
Perimortem trauma				
(a)				
(Intercept)	−1.6	1.2	−1.4	.174
Sex: M	2.4	1.2	2.0	.046
Age: MA	−1.1	1.0	−1.1	.283
Age: OA	−0.7	1.0	−0.7	.477
(b)				
(Intercept)	−17.6	1,978.1	0.0	.993
Age: infant	15.8	1,978.1	0.0	.994
Age: child	16.6	1,978.1	0.0	.993
Age: adolescent	16.9	1,978.1	0.0	.993
Age: YA	17.4	1,978.1	0.0	.993
Age: MA	17.1	1,978.1	0.0	.993
Age: OA	16.7	1,978.1	0.0	.993
Slice marks				
(c)				
(Intercept)	−2.6	1.4	−1.9	.057
Sex: M	1.4	1.3	1.1	.274
Age: MA	−18.2	3,742.8	0.0	.996
Age: OA	1.0	1.1	0.9	.375
(d)				
(Intercept)	−19.6	5,377.0	0.0	.997
Age: infant	0.0	6,740.0	0.0	1.000
Age: child	17.7	5,377.0	0.0	.997
Age: adolescent	18.9	5,377.0	0.0	.997
Age: YA	17.9	5,377.0	0.0	.997
Age: MA	0.0	6,585.0	0.0	1.000
Age: OA	18.7	5,377.0	0.0	.997

Note: Reference levels in models (a,c) = F and YA; Reference level in models (b,d) = Age: Neonate.
Abbreviations: M, males; MA, middle adults; OA, old adults.

(Figure S5h), whereas the absence of daggers may be related to the practical reasons postulated for the absence of swords.

4.1.3 | Penetrating lesions and blunt trauma

The triangular and diamond-shaped penetrating lesions can be tentatively linked to trilobate and rhomboidal arrowheads similar to those found at Tunnug1 (Figure 4d,g). However, also alternative hypotheses for these lesions should be considered, including their association with spears (cf. Khudjakov, 2005) or possibly pick axes. The rectangular lesion on the posterior surface of a left scapula likely resulted from a partial piercing of the bone by a pointed weapon (arrowhead, spear or battle-axe). A similar lesion was found, on the same location, in a

FIGURE 6 Detail of Sk36 (Child) with arrowhead (white rectangle) found in situ at the level of the lower thoracic area; *left*: the arrowhead after restoration

Hunno-Sarmatian skeleton from Aymyrlyg, and similarly attributed to the partial penetration of an arrowhead (E. M. Murphy, 2003a, plate 56).

The high fragmentation of the humeral diaphysis in the single case of blunt trauma points to a high-force impact to the upper arm. The lack of well-defined lesion margins and the absence of maces or similar weapons at Tunnug1 hampers more precise reconstructions. Blunt traumas have been identified also at Aymyrlyg (E. M. Murphy, 2003a). This suggests that the nomadic people of Southern Siberia used blunt objects in interpersonal confrontations in addition to bladed weapons, arrows and spears.

Antemortem lesions at Tunng1 appear mostly of accidental origin, possibly due to falls leading to indirect trauma to the upper and lower limbs and direct blunt traumas to the thorax (Lovell, 1997). Only in two cases (on the left parietal bone and on the acromial end of the left clavicle in two old adult males), the lesion can be tentatively attributed to a sharp force trauma. The heavy remodeling of the affected bones hampers however a clear interpretation.

4.2 | Anatomical distribution

4.2.1 | Chop marks

Chop marks are more frequent on the cranium, mandible, and upper vertebral column (Table S2). In almost all affected individuals multiple lesions are documented on various bones, with blows originating from different positions. In the literature multiple perimortem lesions are frequently observed on victims of hand-to-hand combats in preindustrial contexts (Ingelmark, 1939; Jiménez-Brobeil et al., 2014; Kjellström, 2005; Łukasik, Krenz-Niedbała, Zdanowicz, Różański, & Olszacki, 2019; Murphy, 2003a; Novak, 2000; Pankowská, Galeta, Uhlík Spěváčková, & Nováček, 2019; Tumler, Paladin, & Zink, 2019; Tur et al., 2018). They may result from the attempt to incapacitate an opponent hitting them repeatedly, and/or by the attack by multiple aggressors in crowded battlefields (see Knüsel & Boylston, 2000; Novak, 2000).

Chop marks perpendicular to the top of the cranial vault and at the level of the lower limb (Table S2) may indicate that the aggressor or victim, respectively, were in an elevated position (see also Ingelmark, 1939; Karasulas, 2004; Kjellström, 2005; Knowles, 1983). When considering that steppe nomads traditionally used horses during combat, we can therefore assume that part of the confrontations documented at Tunnug1 involved mounted warriors.

Chop marks on the upper cervical vertebrae, mastoid processes, mandibular angles, and clavicular shafts are usually attributed to decapitation (cf. Boylston, Knüsel, Roberts, & Dawson, 2000; Buckberry & Hadley, 2007; Geber, 2015; Kjellström, 2005). At Aymyrlyg, 4% (5/126) of individuals presented vertebral lesions consistent with decapitation (E. M. Murphy, 2003a). In comparison our individuals with traces of decapitation are rather numerous (19/87:21.8%). At Tunnug1 only two individuals present both chop marks pointing to decapitation (Skeletons 42, a young adult male, and Skeleton 46, an old adult male) and the displacement of the skull (Figure S5a,c,g). The preservation of the anatomical connection between the skull and vertebral column in the other cases with chop marks may indicate that the neck was only partially severed (cf. E. M. Murphy, 2003a, p. 90). This probably resulted from the blow being not enough forceful to completely severe the vertebral column. Archaeological cases of decapitation often show multiple traumas to the cervical vertebrae. This suggests that a single blow is not always adequate to completely severe the skeletal and soft tissues of the neck (Tucker 2012). Especially if the attacks were carried on moving targets, the resulting blow may have been less precise and effective.

In the Chinese *Shi Ji*, or *Historical Records*, it is narrated that the Xiongnu, a coalition of nomadic tribes, used to collect the heads of enemies as war trophies (Watson, 1993). The information provided by the *Shi Ji* can only be loosely applied to Tunnug 1, since they refer to a different and older (of about two centuries) cultural setting. Nonetheless, one is left wondering if head hunting may be the reason for the decapitations observed in this study. This however does not seem the case, since here all individuals with traces of decapitation preserve their cranium and mandible.

Only one skeleton (Skeleton 67, an old adult female) presents features hinting at a detachment and collection of the head. No traumas were observed, but the individual was missing the cranium, mandible and first four cervical vertebrae. An iron knife and a sheep vertebra were found at the level of the missing skull (Figures S3b and S5g,h). Combined with the absence of skeletal elements, the specific position of these objects may suggest their purposeful placement, rather than a random inclusion in the burial fill. Although it is possible that the knife was used for the detachment of the head, this hypothesis cannot be tested. It would require a comparison between the shape and size of the knife's blade and possible slice marks on the skeleton. However, the first cervical vertebrae are missing, and no slice mark was found on the other skeletal elements of this individual. The fact that this individual was an old female (females are characterized by markedly low frequencies of trauma at Tunnug1—see below) makes this finding of great interest.

If excluding head hunting, the observed lesions may be linked to combat, executions, and rituals. The head and neck would have been ideal targets during combat (cf. Novak, 2000), and a combat scenario is supported in six individuals (32% of individuals with traces of decapitation) by the presence of additional perimortem traumas on the skeleton besides decapitation.

Decapitations may also have been carried out during executions (e.g., of enemies or social transgressors), or sacrifices. Both Herodotus and the *Shi Ji* document the performance of violent sacrifices by steppe nomads (Annibaletto, 2007; Watson, 1993). The performance of violent rituals at Tunnug1 seems further documented by evidences of throat slitting and scalping (see below). The attribution of at least some of the decapitation to execution or rituals is also consistent with the absence of chop marks to the upper limb, difficult to explain given the exposure of this anatomical region (especially the forearm) during hand-to-hand combats (see Novak, 2000).

In summary, chop marks at Tunnug1 seem related to various, different modes of interpersonal violence. Part of the individuals were likely victims of hand-to-hand combats, but we cannot exclude that at least some of the lesions resulted from either executions or rituals (i.e., sacrifices).

4.2.2 | Slice marks

All individuals with slice marks preserve their cranium. We can therefore reject an association between these lesions and disarticulations of the head from corpses (cf. Andrews, Molleson, & Boz, 2005; Kanjou, Kuijt, Erdal, & Kondo, 2015). A more likely explanation is throat slitting, as hypothesized for similar evidences in other archaeological contexts (Buckberry & Hadley, 2007; Klaus, Centurión, & Curo, 2010; E. M. Murphy, 2003a; Verano, 2001, 2008).

Possible contexts for throat slitting may include combats (e.g., to finish off an opponent), executions and rituals. A causation during combats seem unlikely, especially due to the association between these lesions and chop marks to the cervical vertebrae (see section 3.3.2). This pattern, previously observed also on a subadult Scythian skeleton from Aymyrlyg (E. M. Murphy, 2003a), points to careful and specifically aimed actions, hardly consistent with the hectic clashes expected during a battle or raid. Conversely, the same features would support the hypothesis of executions or sacrifices by means of blows to the neck and throat slitting.

The slice marks on the crania of Skeletons 42 and 68 are consistent with published cases of scalping (e.g., E. M. Murphy, 2003a; E. Murphy et al., 2002; Smith, 1995, 2003), and would indicate the cut of the skin along the perimeter of the cranium. Similar lesions have been observed in other contexts from Southern Siberia both contemporary to and predating the individuals from Tunnug1 (E. M. Murphy, 2003a; E. Murphy et al., 2002; Tur et al., 2018). The presence of additional perimortem traumas on the scalped individuals from Tunnug1 may suggest that in both cases this practice was performed on vanquished enemies, as a mean to obtain war trophies (see also E. M. Murphy, 2003a).

4.2.3 | Penetrating lesions and blunt traumas

Penetrating lesions and blunt traumas at Tunnug1 are few when compared with chop marks and slice marks. Considering however that the majority of injuries to the body usually do not leave skeletal traces (Knüsel, 2005; Walker, 2001), an underestimation of these lesions is likely. In particular arrowheads may leave few skeletal traces due to their reduced size, especially on those anatomical regions provided with more soft tissues (e.g., abdomen). This is exemplified by Sk36, a child (Figure 6) found with an iron arrowhead transfixing the lower thoracic area, but lacking any trauma on the vertebral column or ribs.

The context of the blunt trauma may have been either a combat, an execution, or a violent ritual. The same can be argued for the penetrating lesions, although battles or raids would be more likely scenarios if distance weapons (i.e., arrowheads) produced these traumas.

4.3 | Demographic patterns

The higher frequency of males with perimortem trauma is consistent with similar results from archaeological contexts geographically and chronologically comparable with Tunnug1 (Alekseev & Gokhman, 1970; E. M. Murphy, 2003a; Tur et al., 2018). This pattern suggests that males were more involved in violence encounters, and warfare activities and therefore more prone to fall victim to combats, execution, and/or sacrifice. This does not however exclude the active involvement of women in combat activities (cf. Ishjamts, 1994). The imbalance in sex representation at the site (63.2% males vs. 36.8% females), is interesting given the possibility to be a result of raids carried out by other groups including the capture of women. This scenario, although possible, however, cannot be tested for the moment.

At Tunnug1, perimortem lesions have been found on both adults and subadults, and these two groups do not differ in the frequency of chop marks and slice marks. The lack of correlation between adult age classes and presence of traumas indicates that individuals were likely to be exposed to violent interactions (e.g., involved in warfare) throughout their adult life. Conversely, the presence of perimortem traumas among subadults may be due to different factors. First, younger subadults may have been easy targets during raids from other groups. The absence of skeletal trauma among neonates and infants would not contradict this hypothesis, being probably the result of a minor preservation of lesions on the fragile skeletal elements of extremely young individuals. Second, the presence of traumas among older subadults (children and adolescents) could be due to the involvement of individuals in warfare activities beginning from a young age (cf. E. M. Murphy, 2003a). Furthermore, if part of the traumas were inflicted during rituals, it is possible that in these contexts the age of the victim played only a minor or no role.

Due to their reduced number, penetrating lesions and the single blunt trauma were not statistically tested regarding their demographic distribution. With one exception, however, all these lesions were found on adult males. This result supports the hypothesis of a higher exposure of men to violent deaths probably due to their higher involvement in warfare activities, a pattern largely shared by most human cultures (e.g., Fibiger et al., 2013; Jiménez-Brobeil et al., 2014; E. M. Murphy, 2003a.).

4.4 | Funerary patterns

The deposition of more individuals with perimortem trauma in seemingly multiple burials (Figure 1c) suggests that they were killed during single violent events. The performance of mass executions, although a possibility, does not seem likely, especially considering the careful funerary treatment offered to these individuals. We need however to consider that few information is available about the funerary practices for this region and time period. It is possible that executed individuals were accorded a proper burial, or that nuanced differences in ritual did not leave notable archaeological traces.

Radiocarbon date estimates for individuals with perimortem trauma point to their death between the third and fourth centuries CE, similarly to the majority of the dated individuals from Tunnug1. It is, however, difficult to estimate if individuals with trauma from different burials died at the same time or rather in the context of different events. The clustering of burials with more individuals in the eastern and central areas of the cemetery may however be related to a more narrow chronology for these interments, although not verifiable by the broad radiocarbon dating intervals (Table 2).

The origin and possible significance of Structure 17 are unclear. The large number of buried individuals, the heavy commingling of the skeletal remains, and the roughly central position of this structure (Figure 1) may suggest a specific meaning. On the other hand, the position of Structure 17 in relation to the other burials may just be a byproduct of the use, and extension, of the funerary area through time. The specific disturbance to the skeletal remains is likely the result of looting activities (see Section 3.5).

Previous studies have suggested a link between high frequencies of skeletal trauma and a decrease in political stability in Southern Siberia, especially between the third and fifth centuries CE (Tur et al., 2018). The data from Tunnug1 provide additional evidence about the effects of such instability on the levels of violence experienced by the people inhabiting these regions.

5 | CONCLUSIONS

The type, anatomical distribution, and demographic patterns of perimortem trauma analyzed in this study suggest that a large part of the individuals buried at Tunnug1 died either in the context of hand-to-hand combats, raids, execution or violent rituals. The presence of several individuals with multiple, potentially lethal, lesions and traces of throat slitting and scalping demonstrates that violence was a relevant cultural trait of the nomadic people living in Tuva during the early centuries CE. These data integrate the results from previous studies on similar archaeological contexts, while at the same time helping to better contextualize available historical descriptions of these societies.

Our data provide the opportunity to observe how the political turmoil characterizing Southern Siberia and Northern China during the early centuries CE directly influenced the life of the people inhabiting these regions.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Marco Milella: Conceptualization; data curation; formal analysis; investigation; methodology; validation; visualization; writing-original draft; writing-review and editing. **Yulija Kapinus:** Formal analysis; investigation; methodology; validation. **Timur Sadykov:** Formal analysis; funding acquisition; investigation; supervision; visualization; writing-original draft. **Jegor Blochin:** Data curation; funding acquisition; investigation; methodology; software; supervision. **Anna Malyutina:** Formal analysis; investigation; writing-review and editing. **Marcel Keller:** Resources; writing-review and editing. **Stefan Schlager:** Resources; software; writing-review and editing. **Sönke Szidat:** Formal analysis; methodology; writing-review and editing. **Amelie Alterauge:** Data curation; investigation; resources; writing-review and editing. **Sandra Lösch:** Conceptualization; funding acquisition; project administration; resources; supervision; writing-review and editing; **Gino Caspari:** formal analysis; funding acquisition; investigation; resources; writing original draft; writing-review and editing.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

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