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First evidence of human bone pendants from Late Mesolithic Northeast Europe

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ABSTRACT

In this paper, we introduce the first evidence of the use of human bone for making pendants in Northeast Europe. Twelve of the 37 studied pendants made of long bone splinters turned out to be human bone. Here, we present the ZooMS (Zooarchaeology by Mass Spectrometry) identifications of artefacts and their traceological analysis, and we discuss their implications for the archaeology of Mesolithic burial practices. Our results indicate that the raw material for some of the items was in a fresh or semi-fresh state before making pendants. They were used before they were placed into the graves, and most likely in the same ways as animal bone pendants. This is the first study that has found the use of human bone as raw material in Russian Karelia and the first time that the ZooMS method has been applied to archaeological materials from this region. Together with previous human bone artefact finds from the European Mesolithic period, the bone pendants from Yuzhniy Oleniy Ostrov indicate that the tradition of using human bone as raw material may have been widespread.

1. Introduction

Animal tooth and bone pendants are important finds in Stone Age burials in Europe. Very often they are made of complete or almost complete specimens which can be identified to the element and species. Most pendants have been made of mammalian bones and teeth, and sometimes bird or fish bones have been used as raw material as well.

Human remains were also manufactured into pendants and other artefacts in Mesolithic Europe. In Scandinavia, perforated human teeth are known from Late Mesolithic graves at Vedbaek Henriksholm-Bøgebakken in Denmark (c. 6,000 cal BC) (Brinch Petersen, 2016). Perforated human teeth have also been found at Early Mesolithic (Maglemose culture 9,000–6,000 cal BC) settlement sites Sværdborg I-1943 in Denmarkand Friesack 4 in Germany (Brinch Petersen, 2016: 55–56), at Early Neolithic Çatalhöyük (Central Anatolia, Turkey, c. 6700–6300 cal BC) (Haddow et al., 2019) and in Neolithic and Bronze age graves in Zvejnieki, northern Latvia (David, 2006). The earliest evidence of the use of human bone as raw material for ornaments is the perforated teeth in Aurignacian (35,000–31,000 cal BC) sites in France (Vanhaeren and d'Errico, 2006). Slightly younger are the human tooth pendants from Upper Paleolithic (c. 29,000–27,000 cal BC) sites at Pavlov I and Dolní Věstonice I in the Czech Republic (Sázelova and Hromadová, 2020).

Other types of human bone artefacts in Europe are, for example, a human radius with engravings of a series of notches, which was found from the site of Lepenski Vir in Serbia (probably Late Mesolithic) (Wallduck and Bello, 2016), and a rib with incised parallel lines or notches found in a Mesolithic grave at Téviec in France (Schulting, 1996). Mesolithic point tools made from human bone and deriving from ancient Doggerland (today Dutch North Sea) (c. 9,500–7,500 cal BC) have been identified by means of Zooarchaeology by Mass Spectrometry (ZooMS) (Dekker et al. 2020). This method uses collagen or other proteins preserved in archaeological finds to identify the species from which they derive (Buckley 2018). The oldest tools made of human bones are from the Mousterian site La Quina (c 53,000–33,000 cal BC) in France, where three human cranial fragments have been interpreted as retouchers (Verna and d'Errico, 2011). Scrapers were made from human bone in later periods, in the Bronze Age sites Brankovice and Ivanovice

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in Moravia (Parma et al., 2011).

This article focuses on human bone pendants found in the graves at Late Mesolithic Yuzhniy Oleniy Ostrov, situated on Lake Onega in the Karelian Republic, Northwest Russia. It is the largest Late Mesolithic (c. 6200 cal BC) cemetery in Northern Europe with 177 registered inhumations (Gurina, 1956, Schulting, et al., 2022). The burial site was excavated in 1936–1938 by Russian archaeologist J.F. Ravdonikas (Ravdonikas, 1956). (Fig. 1).

Most of the burials contain human skeletal remains and a rich inventory of bone and stone artefacts. Systematic descriptions of graves and their artefacts were given by N.N. Gurina in a monograph "Оленеостровский Могильник", published in 1956. The grave inventory reveals artefacts of bone, teeth and antler (for example, harpoons, points and pendants), flint and quartz utensils and mostly finished flint arrowheads (Gurina, 1956). The most common osseous artefacts are pendants made from the teeth of the Eurasian elk (*Alces alces*), Eurasian beaver (*Castor fiber*) and brown bear (*Ursus arctos*) (Gurina, 1956, Mannermaa et al., 2021). In addition to teeth, pendants were also made from splinters of mammalian long bones and cervid hyoid bones and occasionally from beaver ulna, wild boar (*Sus scrofa*) incisors, elk molars and elk petrous bone. All such pendants, with some bear and wild boar teeth with perforations as exceptions, were manufactured by making one or several grooves on the narrower end of the specimen (Gurina, 1956, Mannermaa et al., 2021).

Pendants made from long bone splinters from Yuzhniy Oleniy Ostrov burials lack morphological species-specific features, and it is not possible to identify their raw materials based on morphology. Since we are interested in understanding the uses of animals in the burial practices at Yuzhniy Oleniy Ostrov, we wanted to determine what raw materials were used for the various artefact types that were deposited in the graves. In order to identify the raw material of these pendants, we subjected some of them to an analysis of ZooMS. To our surprise, the raw material of some of the specimens turned out to be human bone.

In this study, we:

1) present the results of the ZooMS analysis that was made to identify the species used in the production of the bone pendants from Yuzhniy Oleniy Ostrov graves
2) conduct a traceological investigation of the human bone pendants in order to understand their manufacturing technology and use wear
3) conduct a traceological investigation of the animal bone pendants from the graves with human bone pendants
4) investigate the find contexts of the human bone pendants, and
5) discuss why human bone was used as raw material and what these human and animal bone pendants signify in the context of a Mesolithic archaeological burial.

2. Material

At Yuzhniy Oleniy Ostrov bone pendants were found in 22 burials belonging to males and females (Gurina, 1956). Burials 68 and 113 have the highest number of such pendants, 27 and 30 respectively (Gurina, 1956:143). Most graves have between one and four bone pendants. The material investigated in this study consists of 37 long bone fragments, fashioned into pendants, from six graves: 68, 69, 87, 108, 113 and 146. They belong to collection number 5716, which is stored in the archaeological section of Peter the Great Museum of Anthropology and Ethnography (Kunstkamera) in St. Petersburg, Russia. Two morphological criteria were used to select worked bone material for the ZooMS analysis: 1) the item had a groove or grooves, and 2) the anatomical element or the species that was used as raw material for the artefact could not be identified based on morphology. Pendants that turned out to be made of human bone in the ZooMS analysis were included in a traceological analysis in order to determine the manufacture, functions

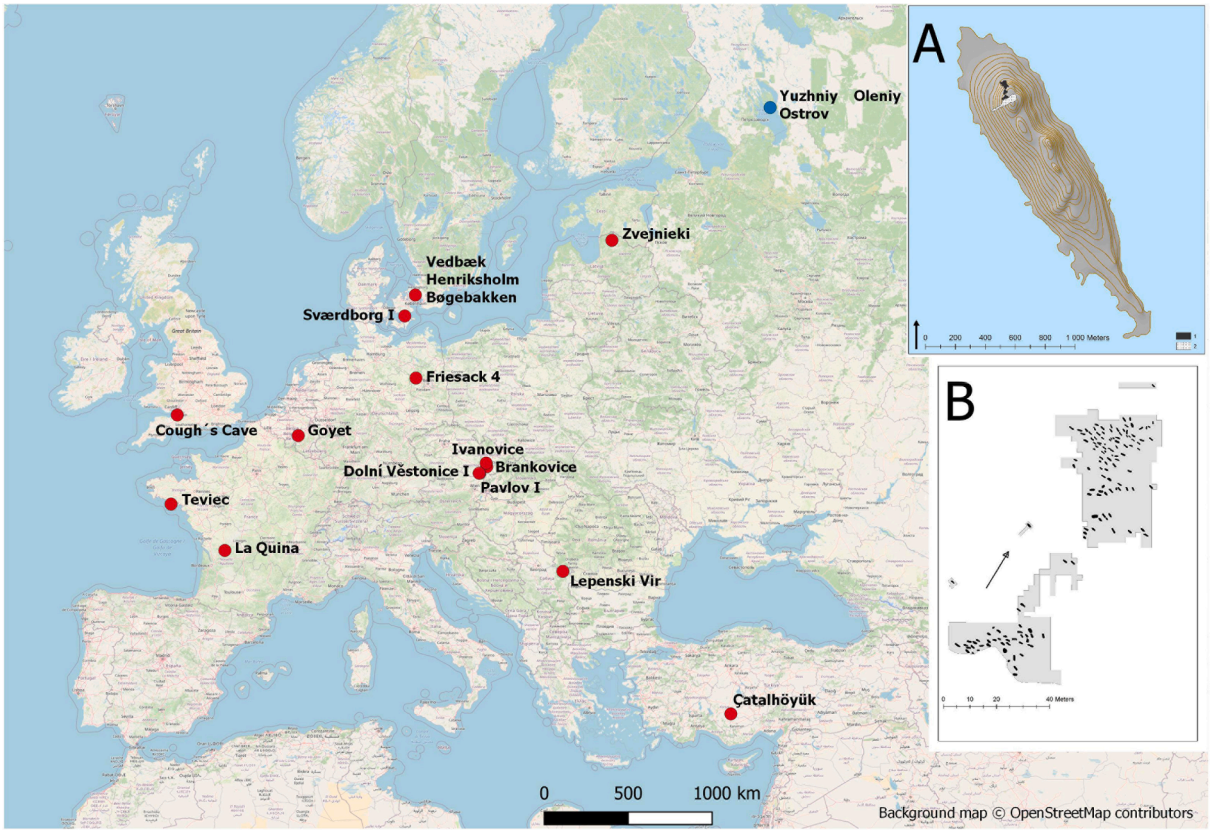


Fig. 1. Locations of the Late Mesolithic burial site Yuzhniy Oleniy Ostrov and some other archaeological sites mentioned in the text. A) The island of Yuzhniy Oleniy Ostrov, the excavation area (black) and the destroyed area (white), B) Map of the graves. Map by Johanna Roiha.

and uses of the objects. Also bone pendants identified as non-human animal bone from these graves and grave 68 were included in the traceological analysis.

The focus of this article is on the bone pendants. Being irregular and without complicated modifications, these items have not been of interest to researchers before our study. N.N. Gurina (1956) described these artefacts, but they have not been studied properly otherwise. Gurina (1956:143–144) argued that these items had been made of bone splinters from long bones of various sizes and shapes that belonged to large mammals and that they had been modestly worked on. Gurina (1956:153) also noticed that grooved bone pendants, animal tooth pendants and hyoid bone pendants were often found together in the same contexts, and she suggested that matte and polish on the outer surface of the pendants indicates that they were used before being deposited in the graves. She describes the largest bone pendants from grave 113: "The largest ones are the almost identical five pendants made of large tubular bones of animals. The items have not been cut or sawed but simply split, indicated by asymmetrically fractured borders. These objects have longitudinal shape and their cross-section is curved. Surface modification is careless, sides may have been flattened a bit, and the spongious bone has been removed. Finishing by polishing is minor or totally missing" (Gurina, 1956:153).

3. Methods

3.1. Zooarchaeology by Mass Spectrometry (ZooMS)

In order to identify the raw materials of the bone pendants, we subjected a sample of bone artefacts with grooves to collagen fingerprinting, ZooMS (van Doorn et al., 2011). ZooMS is a fast method of analysis that allows identification of species from skeletal remains through MALDI-TOF-MS and the subsequent analysis of collagen-peptides (Buckley, 2018, Martisius et al., 2020). The analysis was conducted at the BioArCh laboratory at the Department at Archaeology of the University of York. It was conducted according to routine analysis protocols and methods used for this type of study (e.g. McGrath, et al., 2019, Preslee and Hagan, 2020a).

The bone surface was erased with a sterilized spatula and a tiny amount of bone was scraped inside a plastic bag. The spatula and tweezers were rinsed with distilled water before and after use to prevent any bone powder transfer between samples. Non-powdered laboratory gloves were used when taking the samples. Plastic bags with samples were sent to the laboratory of York, where they were put into individual Eppendorf tubes, and their weight was recorded. 250 μl of 0.6 M HCl was added to the sample before it was placed in the refrigerator at 4 °C to demineralise for 48 h. Once the sample had demineralised, it was removed from the refrigerator and spun down in a centrifuge. The acid was removed, and 200 μl of 0.1 M sodium hydroxide was added to remove any humic contamination from the sample. The Eppendorf was briefly vortexed before being centrifuged, and its supernatant was removed. 200 μl 50 mM of ammonium bicarbonate (AmBic) (pH 8.0) was added in order to 'rinse' the sample. This rinsing process was repeated twice more. 100 μl of AmBic was then added to the sample, followed by an incubation for one hour at 65 °C to release the collagen into the solution. After this, 50 μl of supernatant was transferred to a new Eppendorf that was ready for digestion. 1 μl of sequencing grade trypsin solution was added to the new Eppendorf, and the samples were digested overnight at 37 °C. Following digestion, each sample was centrifuged, and 1 μl of 5% Trifluoroacetic acid (TFA) solution was added to terminate trypsin activity. Peptides were then extracted from the sample solution using C18 ZipTip® pipette tips and eluted with 50 μl of conditioning solution. 1 μl samples were then spotted on to Bruker ground steel target plates and mixed with 1 μl of matrix. Each sample was spotted in triplicate, and the plate was run on the Bruker Ultraflex III MALDI ToF MS.

The accuracy of ZooMS in determining species has some limitations (Welker et al., 2015). For our study, the main limitation is that the method cannot distinguish Eurasian elk (*Alces alces*) from red deer (*Cervus elaphus*) (Presslee and Hagan, 2019, 2020a; Presslee and Hagan, 2020b). Fortunately, ZooMS is a reliable method in identifying human bone. There are currently 14 different primates in the published ZooMS database. Of these, the closely related species of chimpanzee and bonobo share the same markers as humans. However, they can be differentiated from other primates by using the following markers: COL1α2 484 1477.7 *m/z,* COL1α2 793 2115.1 *m/z* and COL1α1 586 2869.4 *m/z.* The identification of human over the other possible primates can be made due to geographical restrictions.

3.2. Traceological analysis of human and animal bone pendants

A traceological analysis was conducted in the archaeology section of Peter the Great Museum of Anthropology and Ethnography (Kunstkamera). The width and length for all the human bone pendants were measured (Table 1). In our microwear analysis we follow the method described in Semenov (1964), Keeley (1980), Peltier and Plisson (1986) and Marreiros et al. (2015). Surfaces of human and animal pendants were investigated with a microscope and potential traces of treatment such as cut marks and traces of planing/ scraping were documented (Sidéra, 1993; Maigrot, 2003; Legrand and Sidéra, 2007; Malyutina and Sablin, 2014). Use-wear like polishing and linear traces were also investigated and documented. Post-depositional processes like root-etching and erosion were also documented, according to Fernández-Jalvo and Andrews (2016).

Several magnifying devices were used in our analysis: an MBS-9 stereo microscope (oblique illumination; magnification up to 98x) and an Olympus metallographic microscope (built-in illumination; magnification up to 500x). The items were documented by using an installation for macro photography with the possibility to microfocus in combination with a Canon EOS 450D camera, Canon Macro EF-S 60 mm 1:2.8 USM and Canon Macro MP-E 65 mm f/2.8 1-5x Macro with oblique external lighting via LED illuminators. The multi-focus image was obtained using Canon EOS Utility and Helicon Focus software.

Two best preserved human bone items were subjected to precise osteological analysis. The anatomical position of the bone fragment was determined through comparison with the reference human bones collection of Kunstkamera's Anthropology department. It includes more than 2000 isolated bones of *Homo sapiens* post-cranial skeletons, obtained during excavations of archaeological sites in various regions of Northern Eurasia but lacking an exact chronological context.

3.3. Find contexts

Find contexts can help in understanding the uses of artefacts, and they can complement the results from the traceological analysis. We were especially interested in determining whether the bone pendants were found in the same contexts or even together with animal tooth pendants. The find contexts of the artefacts were investigated from the grave drawings and descriptions given by Gurina (1956) and from the glass negative photos taken during the excavations. The glass negative photos were obtained from the Archives of the Kunstkamera Museum.

4. Results

4.1. Identification

As a result of the ZooMS analysis, seventeen of the 37 analysed bone pendants turned out to be made from animal bone (Table 2) and twelve from human bone. Two additional pendants were tentatively identified as human (indicated with a question mark). Six of the analysed samples gave poor results and cannot be identified as a species by ZooMS (Presslee and Hagan, 2019, 2020a, b; Presslee and Hagan, 2020b). Human bone pendants were identified in three graves: grave 69 has two,

Table 1
Data of the human bone pendants from Yuzhniy Oleniy Ostrov.

Grave number	№	Width	Lenght	ZooMS result	Anatomical element	Blank/ Manufacture technology	Retained surface	Traces of use	Preservation
Grave 69	a/YOO17	10 mm	55 mm	Human	Long bone diaphysis?	A fragment of the bone splitting?	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing (Fig. 4: a)	Partly destroyed*
	b/ YOO66	13 mm	46 mm	Human	Rib?	Bone fragment	yes	No polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	c/ YOO111	9 mm	42 mm	Poor result	?	Bone fragment	yes	No polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
Grave 108	d/ YOO89	12 mm	46 mm	Human	?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
Grave 113	e/YOO12	18 mm	46 mm	Human	Rib?	Bone fragment	yes	No polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	f/YOO57	15 mm	45 mm	Human	?	Bone fragment	no	No polishing zones and linear traces in the area of the groove for fixing	Heavily destroyed
	g/ (YOO95)	9 mm	50 mm	Human	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing (Fig. 5: 2b)	Partly destroyed
	h/ YOO96	13 mm	46 mm	Human	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	i/YOO97	10 mm	45 mm	Human	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	j/YOO99	27 mm	132 mm	Human	Femur diaphysis	A fragment of the bone splitting	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing and on wide plane (Fig. 5: 1a)	Partly destroyed
	k/ YOO26	11 mm	39 mm	Human	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	l/YOO93	16 mm	65 mm	Human	Femur diaphysis	A fragment of the bone splitting	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing (Fig. 6: a, b)	Partly destroyed
	m/ YOO94	11 mm	23 mm	Human	–	–	yes	No polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	n/ YOO23	12 mm	34 mm	Human	Long bone diaphysis?	Bone fragment	no	No polishing zones and linear traces in the area of the groove for fixing	Heavily destroyed
	o/ YOO24	8 mm	27 mm	Human	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing	Partly destroyed
	r/YOO98	17 mm	50 mm	Poor result	Long bone diaphysis?	Bone fragment	yes	In the form of minimal polishing zones and linear traces in the area of the groove for fixing (Fig. 5: 3c)	Partly destroyed

* - partly destroyed surfaces – this is a partially destroyed outer layer of the periosteum; heavily destroyed surfaces – this is a completely destroyed layer of the periosteum.

grave 108 has one and 113 has nine human bone pendants.

When we started the study, we were able to say that all the bone pendants were made of long bones, but we were not able to identify which specific bones were used. After the ZooMS results we re-analysed the two best preserved human bone specimens, pendants 5716: 502 (YOO99) and 5716–516 (YOO 93), both from grave 113 (Table 3l, j). They turned out to derive from the same bone (see Section 4.3) and could be identified as a human femur.

4.2. Contexts of the human bone pendants

Three graves with human bone pendants are 69, 108 and 113; however, 108 is part of a double grave of one adult (108) and one child (109). Drawings and photos of these graves, with the distribution of the grave finds based on Gurina (1956), are presented in Fig. 2a-c.

In grave 69, bone pendants were found together with elk tooth pendants, indicating that they most likely were all hanging together, perhaps on the hem of a coat or a cloak (Rainio et al., 2021). In grave 113, human bone pendants were also found in the same context as animal tooth pendants. In grave 108, human bone pendants were found below the mandible of the deceased together with another bone artefact, a pierced bone that was identified by ZooMS as lynx (*Lynx lynx*) or wild cat (*Felis silvestris*) (Mannermaa et al.,forthcoming).

4.3. Traceological analysis of the human bone pendants

For the traceological analysis of manufacture and use traces, sixteen pendants made of human and fifteen made of animal bone were selected (Table 2). The preservation of artefacts is poor: in most cases, the original surface has been destroyed by erosion, where we distinguish partly destroyed surface (partially destroyed outer layer of the periosteum) or heavily destroyed surfaces (completely destroyed layer of the periosteum) Their sizes and shapes vary (Tables 1 & 3).

As a result of the analysis of the human bone pendants, it was found that two of them (Table 3j, l) from grave 113 are made of one long bone. The contours of the splitting of the original bone coincided with these two pendants (Fig. 3). Some other pendants from this burial (for example, Table 3g, r) were probably also made of this one long bone, but the erosion of the surface did not allow them to be connected. According to this reconstruction, we can conclude that the production of blanks for the manufacture of these two pendants occurred as a result of direct splitting of the bone (Goutas et al., 2018: 80, Fig. 2 a, c). Probably, in a similar technique, a blank was obtained for another item (Table 3a). We cannot establish a method for obtaining blanks for the remaining

Table 2
Data of the items from the graves at Yuzhniy Oleniy Ostrov used in this study. As for animals, many of our samples were identified as red deer or as red deer or elk. However, we have no evidence of the presence of red deer in Karelia during the Stone Age. For this reason, we assume that all identifications to red deer or elk derive from elks. Another limitation is that the method cannot identify Bovid species, which include bison (*Bison bonasus*), aurochs (*Bos primigenius*) and domestic cattle (*Bos taurus*). In our material, three samples were identified to bovids, but it is not possible to identify which species. Domestic cattle was not kept in Karelia in the Mesolithic, so our samples must derive from bison or aurochs (Mannermaa et al, in prep.).

Museum Number	Grave number	ZooMS number	ZooMS result	Original field Number	Traceology
5716–256	68	YOO13	Red deer/ Elk	2593	Yes/Fig. 7: 1
5716–256	68	YOO14	Red deer/ Elk	2369	Yes/Fig. 7: 2
5716–256	68	YOO15	Poor result	2374	Yes/Fig. 7: 3
5716–256	68	YOO51	Bovidae/ Cervidae	2375	Yes/Fig. 7: 4
5716–256	68	YOO52	Bovidae	2376	Yes/Fig. 7: 5
5716–256	68	YOO53	Bovidae/ Cervidae	2371	Yes/Fig. 7: 6
5716–256	68	YOO54	Bovidae	2368	Yes/Fig. 7: 7
5716–256	68	YOO55	Red deer/ elk	2370	no
5716–256	68	YOO56	Red deer/ elk	2366	Yes/Fig. 7: 8
5716–256	68	YOO58	Red deer/ elk	2378	Yes/Fig. 7: 9
5716–255	68	YOO59	Poor result	2357	Yes/Fig. 7: 11
5716–256	68	YOO60	Red deer/ elk	2364	Yes/Fig. 7: 10
5716–256	68	YOO61	Poor result	2367	Yes/Fig. 7: 12
5716–256	68	YOO62	Bovidae/ Cervidae/ Horse	2373	Yes/Fig. 7: 13
5716–255	68	YOO63	Bovidae	2522	Yes/Fig. 7: 14
5716–256	68	YOO64	Red deer/ elk	2372	Yes/Fig. 7: 15
5716–255	68	YOO65	Red deer/ elk	2361	no
5716–268	69	YOO17	Human		Yes/ Table 3: a
5716–268	69	YOO66	Human		Yes/ Table 3: b
5716–367	87	YOO84	Bovidae/ Cervidae		no
5716–473	108	YOO89	Human		Yes/ Table 3:d
5716–503	113	YOO23	Human		Yes/ Table 3: n
5716–503	113	YOO24	Human	4611	Yes/ Table 3: o
5716–516	113	YOO26	Human	4666	Yes/ Table 3: k
5716–256	113	YOO57	Human?	4580	Yes/ Table 3: f
5716–255	113	YOO12	Human	4576	Yes/ Table 3: e
5716–503	113	YOO25	Poor result	4583	no
5716–512	113	YOO112	Poor result		no
5716–516	113	YOO93	Human	4664	Yes/ Table 3: l
5716–517	113	YOO94	Human?	4665	Yes/ Table 3: m
5716–502	113	YOO95	Human	4579	Yes/ Table 3: g
5716–502	113	YOO96	Human	4577	Yes/ Table 3: h
5716–502	113	YOO97	Human	4581	Yes/ Table 3: i
5716–502	113	YOO98	Poor result	4590	Yes/ Table 3: r
5716–502	113	YOO99	Human	4573	Yes/ Table 3: j
5716–681	146	YOO103	Bovidae/ Cervidae		no
5716–681	146	YOO104	Red deer/ elk		no

pendants. However, it cannot be excluded that the formation of such transversally broken flakes is due to sedimentation or compaction by post-depositional and post-burial factors (Fernández-Jalvo and Andrews, 2016: 284, 291, Fig. A. 962).

One human bone pendant (Table 3a) has longitudinal traces of planing/scraping by a stone tool in the area next to the grooves (Fig. 4b). It was found that the traces of planing/spread along the surface of the bone next to the grooves and are partially overlapped by the traces of sawing, which indicates the pretreatment of the outer layer of the periosteum before the design of the grooves.

Despite the worn surfaces of the human bone artefacts, we can estimate that the production of the pendants was simple. After receiving the blank, one or two grooves were cut into the narrower end. In four cases, the attachment groove extends along the entire wide plane of the bone with maximum reduction at the edges of the blank (Table 3e, j, k, m). According to the preserved contours of the grooves and the traces inside them, sharp stone tools leading to V-sections (Fig. 4, Fig. 5:1) and more blunt tools leading to U-sections (Table 3d) were most likely used for cutting.

Ten human bone pendants have traces of use in the attachment area along the protruding faces and on the wide planes (Table 2). They are characterized by smooth polishing on the protruding areas and short or long thin scratches with smooth edges. In the area of the grooves, the linear traces are mainly located parallel to the grooves (Fig. 4; Fig. 6; Fig. 5:1b;2c), which corresponds to the friction mechanics of the suspension rope. On the side and the protruding faces, where the original surface has been preserved, irregular thin, short or long scratches are visible (Fig. 5:1a). They are likely the result of the iteḿs contact with soft material (leather, fur, hair or plant fibre rope).

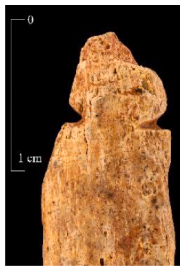
In order to estimate the similarity of the human and animal bone pendants we also studied technological and use-wear features of objects made of animal bone from grave 68 (Table 1; Fig. 7) (grave 68 does not contain human bone pendants). Since this is not in the focus of the present study, we will only briefly present the main points. The blanks for the pendants were fragments of probable bone splitting (Fig. 7: 2–15). The outer layer of the periosteum of two pendants is treated with planing/scraping (2378–2366) in order to flatten the area before making grooves – in a similar manner as we see on human bone pendants. Grooves with V-sections and U-sections were cut at one end of the resulting fragment to fix the items. In six cases signs of wear were recorded, the features of which and their location relative to the characteristics already being described for the human bone pendants.

5. Discussion

5.1. How were the human bone pendants made and used?

ZooMS revealed that both animal and human bone were used as raw materials for bone pendants at Yuzhniy Oleniy Ostrov. The manufacture technology of the human bone pendants was simple. The process

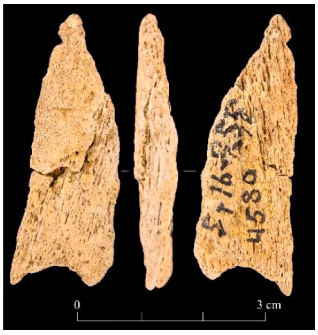
Table 3
Contexts of the human bone pendants from Yuzhniy Oleniy Ostrov. Photos Kristiina Mannermaa, Anna Malyutina and Stas Shapiro/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St Petersburg.

Grave 69 (adult man) **Museum number**	**Context**	**Photo**		**ZooMS result**
a 5716-268 (YOO17)	By the left thigh of the deceased, together with three other grooved bone pendants and elk incisor pendants			Human
b 5716-268 (YOO66)	By the left thigh of the deceased, together with three other grooved bone pendants and elk incisor pendants			Human
c 5716–268 (YOO111)	By the left thigh of the deceased, together with three other grooved bone pendants and elk incisor pendants			Poor result

1

(*continued on next page*)

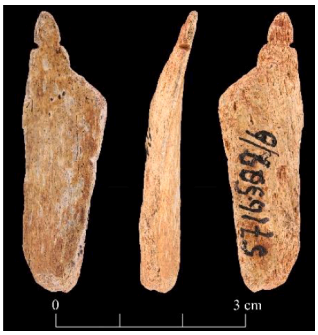
Table 3 (*continued*)

Museum number	Context	Photo	ZooMS result
Grave 69 (adult man)			
Grave 108 (a double grave of an adult man and a child 109)			
Museum number	**Context**	**Photo**	
d 5716-473 (YOO89)	On the chest of the deceased (adult man), found together with fragments of grooved bone pendants.		Human
Grave 113 (adult man)			
Museum number	**Context**	**Photo**	
e 5716-255 (YOO12)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.		Human (double checked)
f 5716-256 (YOO57)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest		Human?
g 5716–502 (YOO95)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.		Human

(*continued on next page*)

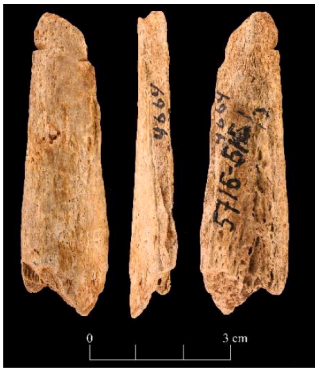
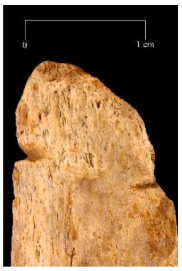
Human

Table 3 (*continued*)

Grave 69 (adult man) Museum number	Context	Photo		ZooMS result
h 5716–502 (YOO96)	At the area of the original position of the skull (the skull was crushed and displaced).			Human
i 5716-502 (YOO97)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.			Human
j 5716–502 (YOO99)	In the area of the original position of the skull (the skull was crushed and displaced).			Human
k 5716–516 (YOO26)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.			Human

(*continued on next page*)

Table 3 (*continued*)

Grave 69 (adult man) Museum number	Context	Photo		ZooMS result
l 5716-516 (YOO93)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.	 **1**	 **2**	Human
m l5716-517 (YOO94)	One of the 25 grooved bone pendants found in the area of the original position of the skull (the skull was crushed and displaced), and on the chest.			Human?
n 5716-503 (YOO23)	Near the pelvic area, together with five other grooved bone pendants, five bear canine pendants and a slate knife.			Human
o 5716-503 (YOO24)	Near the pelvic area, together with five other grooved bone pendants, five bear canine pendants, and a slate knife.			Human (Double checked) Poor result

(*continued on next page*)

Table 3 (*continued*)

Grave 69 (adult man) Museum number	Context	Photo	ZooMS result
p 5716-503c (YOO25)	Near the pelvic area, together with five other grooved bone pendants, five bear canine pendants, and a slate knife.		
q 5716-512 (YOO112)	Near the pelvic area, together with five other grooved bone pendants, five bear canine pendants, and a slate knife.		Poor result
r 5716-502 (YOO98)	One of the 25 grooved bone pendants found at the area of the original position of the skull (the skull was crushed and displaced) and on the chest.		Poor result

consisted of splitting the bone, planing/scraping and cutting a groove or grooves. This treatment is systematic and intentional. Either there was no need or no time for additional processing. The shapes of the cut marks (both V and U detected) indicates that both sharp and blunt stone tools (slate) were used for making the grooves on the human bone pendants. It is interesting that people who had such high standards for processing animal bones, for example, carving figurines and weapons from them (Gurina, 1956), decided to produce such unfinished-looking and robust artefacts from human bone. Our data indicates that treatment of human bone and using it in artefact manufacturing was not necessarily considered different or abnormal behaviour.

The pendants were used before being deposited in the graves. The clearest traces of use are scratches near the grooves, which resulted from contact with some soft material, most likely leather or plant fibre rope. Also, smooth (shiny) surfaces on some items indicate that they were used before deposition in the graves.

The shapes and sizes of the human bone pendants identified at Yuzhniy Oleniy Ostrov are similar to the animal bone pendants. Most of the human bone pendants were also found in the same context as the animal tooth pendants. It can thus be assumed that the human bone pendants were used in a similar way as the tooth pendants: they were attached to separate ornaments, rattles, head gear and clothes (Mannermaa et al., 2021, Rainio et al., 2021). They may also have been attached to objects other than body ornaments (for example baskets, bags and blankets) (White, 2007).

During our systematic study of the pendants from Yuzhny Oleniy Ostrov (Mannermaa, et al., 2021, Rainio, et al., 2021), we paid close attention to the fact that the forms and sizes of these artefacts resemble animal tooth pendants. The similar shape and context of the bone and tooth pendants raises a further question: could these irregularly formed bone pendants, made from human and animal bone, in fact be substitutes for tooth pendants? Elk, beaver and bear were mainly used to make tooth pendants (Mannermaa et al., 2021). One killed animal provided only limited number of teeth. Elks have eight mandibular

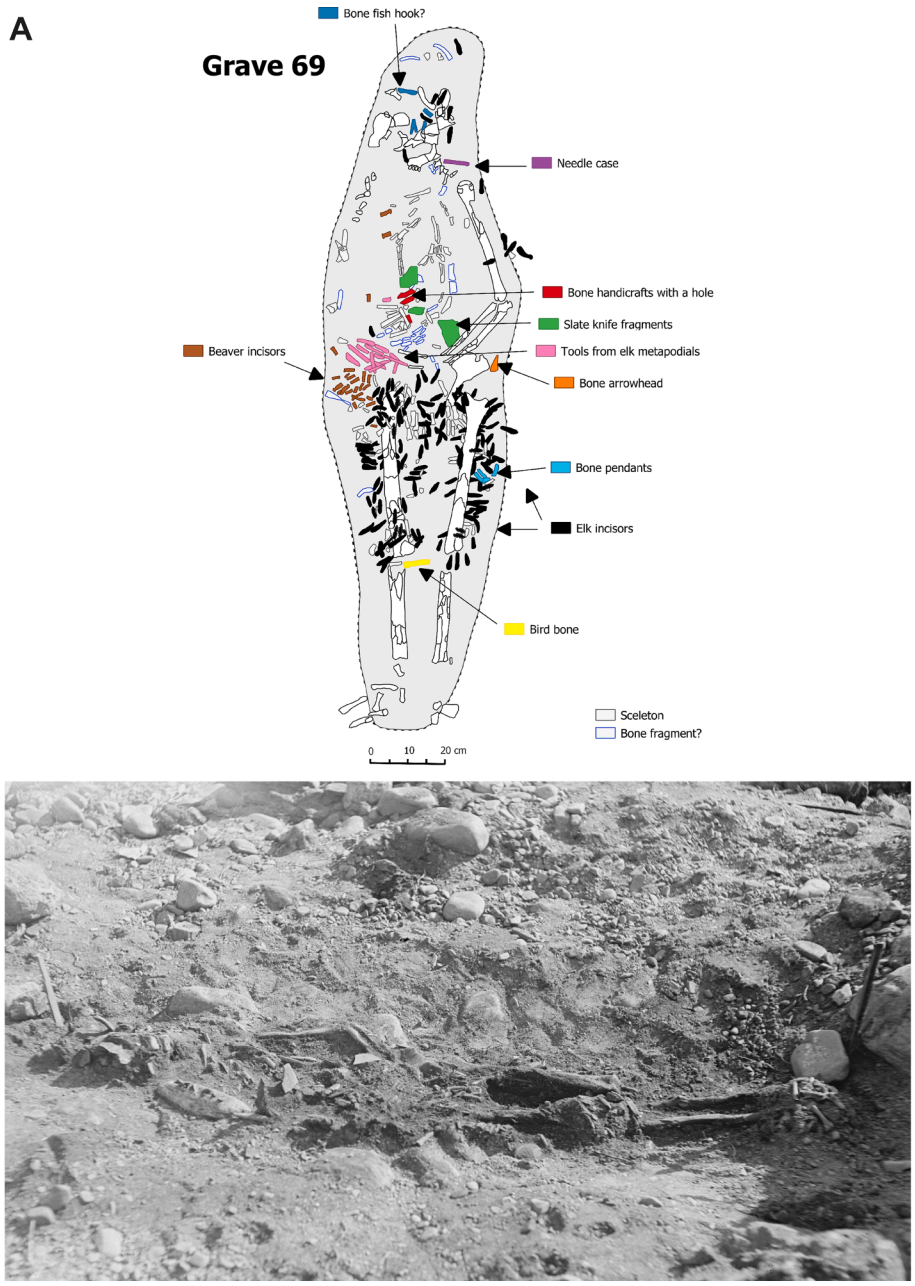
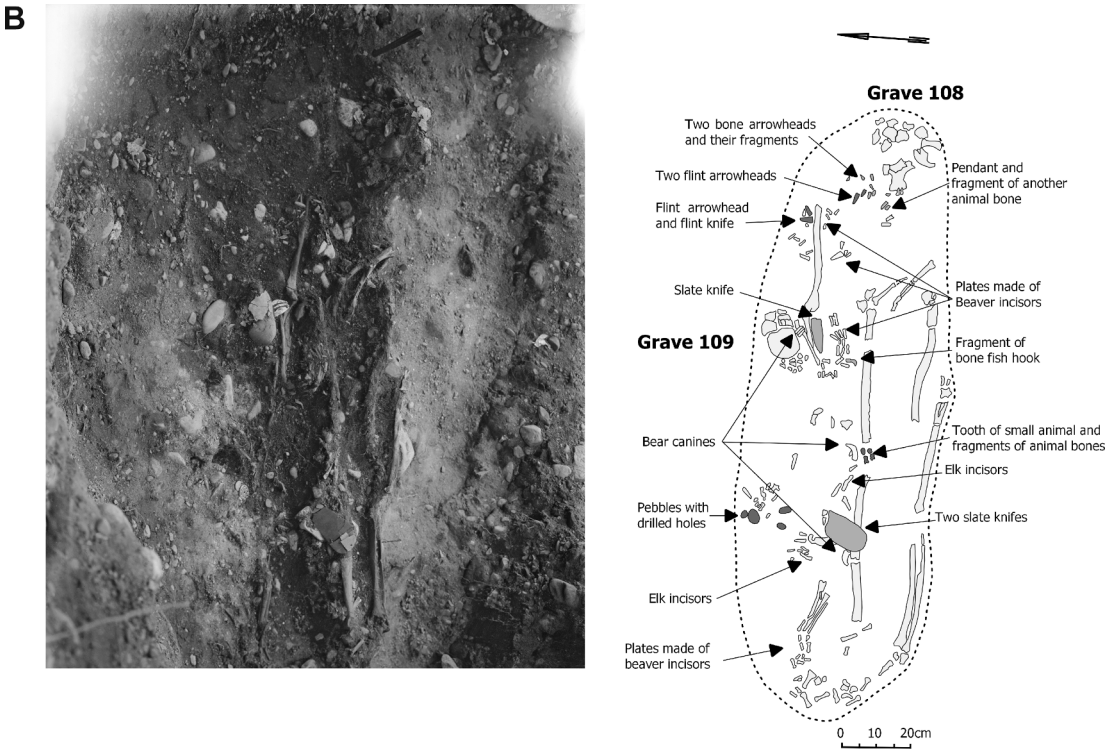


Fig. 2. Graves with human bone artefacts (pointed with arrows) at Yuzhniy Oleniy Ostrov. Drawings and descriptions of finds adopted from Gurina (1956). A) Grave 69. Above: Drawing of grave 69 with finds indicated based on Gurina (1956) (drawing by Johanna Roiha). The skeleton of an adult male was lying on his back at the depth 0.77–0.93 m. The orientation of the head part was to the East. The skull was crushed, and fragments were displaced. The bones of the right arm, vertebrae and the right side of the pelvis were totally missing. The left arm was bent at the elbow, and the left hand bones were on the pelvis. The bones of the legs were preserved and in anatomical order. A layer of deep red ochre covered the skeleton. A bone tube with ornamentation was lying above the right shoulder in a transverse position at the level of the dispositioned upper jaw, about seven centimetres from the teeth (Mannermaa and Rainio, 2020). Elk incisor pendants and small bone artefacts with grooves, identified as parts of composite fishing hooks by Gurina (1956:108–109) were found near the skull fragments. A fragmented slate knife, seven artefacts made of Eurasian elk metatarsal or metacarpal bones, and fragments of flat bone artefacts with holes were in the pelvic area. A bone point was found above the left thigh, and 188 elk incisor pendants were found on the lower part of the pelvis and upper legs. Bird bones were found between the femoral bones; 25 incisor plates of Eurasian beaver were on the right side of the chest and in the upper part of the right thigh, and four grooved bone artefacts were found by the left thigh. Two of these grooved bone artefacts are made of human bone, and one did not give a ZooMS identification result. Found together with the elk tooth pendants, they were most likely all hanging together, perhaps in the hem of a coat or cloak. Below: Photo taken of grave 69 during excavation. Peter the Great Museum of Anthropology and Ethnography, St Petersburg. B) Grave 108 Left: Photo taken during excavation in 1936-1938. Peter the Great Museum of Anthropology and Ethnography, St Petersburg. Right: Drawing of grave 108–109 with finds indicated based on Gurina (1956) (drawing by Johanna Roiha). Description of the grave according to Gurina (1956). Burial 108 was in the same pit as burial 109. Burial 108 has been dated to 7750 ± 110 BP (Hedges et al., 1990; Price and Jacobs, 1990). Skeletons of an adult man and an infant laid almost at the same depth; the skull of the adult in grave 108 at 0.76 m, and the feet of the infant in grave 109 at 1.00–1.01 m. Both had their heads to the east with some declination to the north. Besides the two skeletons in 108 and 109, additional bones of a third individual were discovered in the same area but at a different depth (0.73–0.83 m). Part of these remains, five teeth, was found in the area of the right hipbone of the adult 108. In the same area, but a bit deeper, under the slate knife were the remains of a mandible, and under the left hipbone was a humerus. According to Gurina (1956), the position of bones and the layers of ochre indicate that the grave of the adult and the child is older than the third grave, represented only by occasional teeth and bones. Preservation of the bones of all these individuals is poor. The bones were damaged by time and by roots. A significant part of the skeletal elements is absent, especially from the child

109. The layer of ochre was intensive, especially in the area of the child skeleton 109, and the colour of ochre was strong and bright. Child 109 is represented only by parts of its skull with teeth lying separately, phalanges and two shinbones. The adult man 108 lay on his back, in an extended position: his right hand was bent along the body and his left hand was absent. Other bones were dislocated, and the skull was fragmented. The adult man 108 had a flint arrowhead and knife in the area of the right shoulder. At the left side of the skull were two flint arrowheads, two bone arrowheads and several fragments of arrowheads. On the chest or below the mandible was one complete bone pendant (made of human bone) and a fragment of a pierced bone artefact. At the right hand was a long slate knife and at the right pelvic area was part of a bone fishing hook. At the right shinbone two slate knives were found. Next to the previous ones and at the knees were bear canine pendants (with perforation) and at the right elbow were two bear canine pendants (with perforation). At different parts of the skeleton fourteen bladelets of beaver incisors and sixteen elk incisors were found. At the right hip was a tooth of a small animal and fragments of animal bones. The child 109 had fifteen plates of beaver incisors in the feet area. In the middle part of the skeleton were four polished stone pebbles with drilled holes (one pebble with ten holes, one with three holes, and two with one hole each), and two elk incisors. C) Grave 113. Left: Human bone artefacts found in grave 113 (5617-502); above: YOO 99, below: YOO96 (see Table 3). Photos Kristiina Mannermaa/Peter the Great Museum of Anthropology and Ethnography, St Petersburg. Center: Photo of grave 113 during excavation in 1936–1938. Photo: Peter the Great Museum of Anthropology and Ethnography, St Petersburg. Right: Drawing of grave 113 with distribution of grave finds based on Gurina (1956) (drawing by Johanna Roiha). The description of the grave according to Gurina (1956): skeletal remains of an adult man lay at a depth of 0.70 (skull) and 0.80 m (distal legs). The head was oriented to the southeast. The skeleton was destroyed. The skull was moved to the place of the left humerus, lying on its parietal. Parts of a mandible were found under the skull. The rest of the skeleton is poorly preserved, and many elements are absent. Presumably only the right pelvic bone had its original position at the time of excavation. Red ochre is present but not intensive. The grave pit is oval and has a washing tub-shaped bottom. Here, 25 tubular bone pendants with grooves were found together with elk tooth pendants at the area of the original skull and partly on the chest. Nine of these pendants in the skull and chest area were made of human bone. Next to the skull were six flint arrowheads and one fragmented knife-like bladelet. Near the pelvic area were five bear canine pendants, a slate knife, and five grooved bone artefacts of tubular bones. Two of these grooved tubular bone artefacts in the pelvic area were made of human bone. Near the right hipbone a delaminated slate knife and a bone rod with a hole were found. At different parts of the skeleton, 46 elk incisors (part of them near the skull) and four plates of beaver incisors were found.



incisors (or six incisors and two canines with similar form), beavers have two mandibular and two maxillary incisors, and bears have two mandibular and two maxillary canines. When a pendant broke or was lost, there was perhaps no new tooth available, and a substituting imitation of similar size and form was needed. Several bone pendants from Yuzhniy Oleniy Ostrov (Fig. 8a) are of similar form and size as most of the elk tooth pendants (Fig. 8b) and beaver incisor pendants (Fig. 8e). Two large human bone items in grave 113 are of similar form and size as the bear canines (Fig. 8c-d). Some of the items have a similar form and size as wild boar incisor pendants (Fig. 8f). The shapes of the bone pendants are not exactly the same as animal teeth. Bone fragments were fashioned into pendants simply by adding a groove on the narrower end of the robustly tooth-shaped fragment.

The possibility that these are substitutes for tooth pendants is further supported by the fact that most of the studied bone pendants were found in the same contexts as the tooth pendants. What might have been the reason for using human bone as raw material for them? Why was human bone used to make common artefacts like pendants? The similarity between the human and animal bone pendants suggests that it was not important to express or highlight the use of human bone as raw material. Bone pendants made of human and mammalian bone cannot be distinguished by their appearance. This is interesting because the choice of animal species from which the tooth pendants were made seems to have been important: nearly all tooth pendants in Yuzhniy Oleniy Ostrov graves are made from Eurasian elk and Eurasian beaver incisors or from brown bear canines (Mannermaa et al., 2021).

Potential substitutes of tooth pendants have been documented in archaeological contexts from other regions and contexts as well. For example, red deer (*Cervus elaphus*) canines were substituted with bone imitations in Early Neolithic Çatalhöyük (Russell and Griffitts, 2013), and fossil beads were substituted with bird bones in Neolithic Gotland (Nihlén, 1927: 126). Bone imitations of animal tooth pendants are

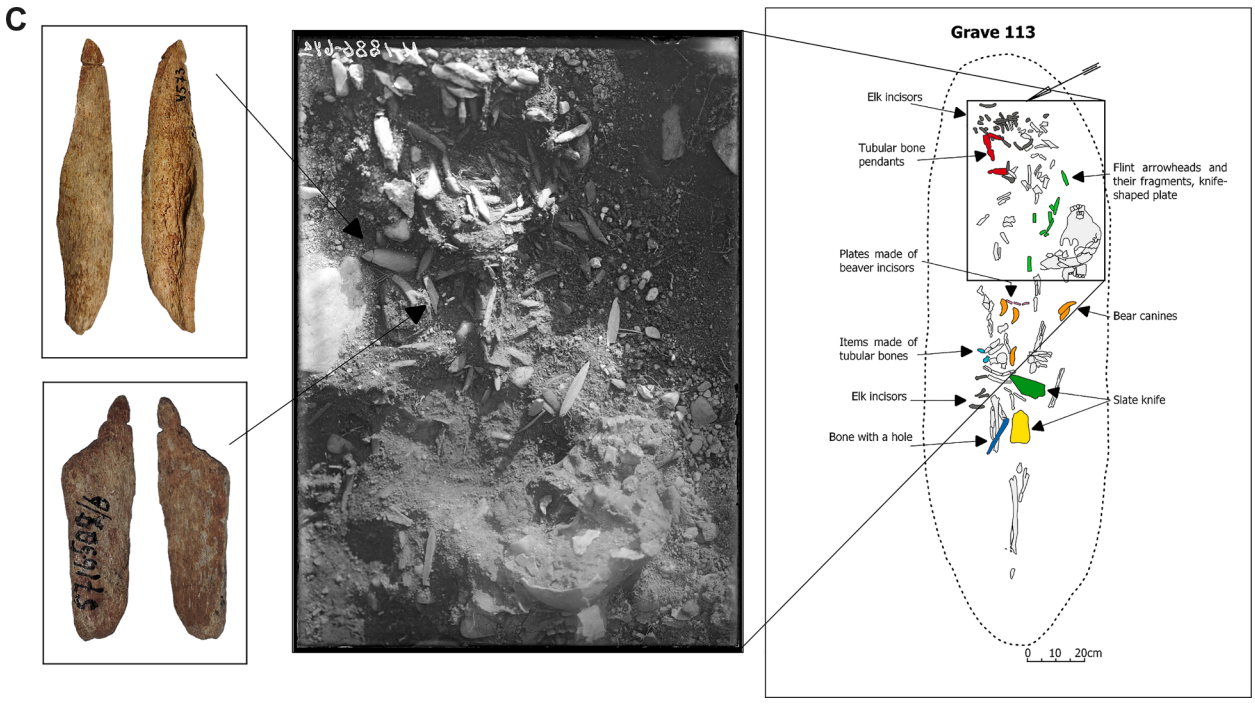


Fig. 2. (*continued*).

known from Neolithic Estonia (Jonuks, pers. comm).

These objects derived from the bodies of the deceased were carried around, and they possibly produced rattling sounds. It is unclear whether the human bone pendants were parts of rattles, but this would not be surprising, considering evidence of human bone musical instruments from other areas and periods. A flute from a cave occupation site in Gaban at Piazzina di Martignano near Trento (6th millennium BC) is made of a human femur (Graziosi, 1975). Hester (1969) reports beads and mouth pieces of pipes that are made from human bone in archaeological burial contexts in ancient Texas, USA. Human bone has been used to make musical instruments for rituals recently as well (Kerner, 2018: 268–270; 278–280). For example, the Tibetan Buddhist culture still uses traditional musical instruments made of human bone in rituals (Terris, 2015).

Gray Jones (2011: 201; see also Cobb and Gray Jones, 2018) suggests that clean human bone may have retained a sense of the individual from which it derived, circulating as a relic of a family member or an ancestor. Alternatively, we can also suggest that the bone was perceived as something else entirely once it had been modified into a pendant and carried together with similar artefacts made of animal bones. To make an animal tooth imitation out of human bone may carry a symbolism known from other contexts, namely the notion of the transformation and fluidity of beings and things (Conneller, 2004, Willerslev 2007, Živaljević, 2015). According to such a view, humans can transform into animals and animals can transform into humans by using implements (for example, body parts such as bones or feathers or artefacts and their sounds). Merging pendants made from the raw material of humans and animals could have symbolized the need or ability to alter one's state of being, from human to elk, beaver or bear and/or the other way around.

5.2. Where was the raw material taken from?

Human bone is used for ritual purposes even recently. The tradition of taking parts of killed enemies as trophies is known among some historical indigenous tribes (Hoskins, 1989; Okumura and Siew, 2013). Such acts often reflect the intention to frighten and display power over other people. Ethnographic evidence exists of using human bones as decorative pendants, family items, religious relics, talismans or magical items (Brinch Petersen, 2016, Kerner, 2018: 304–319).

Raw material for pendants could be taken from dead relatives, or they may originate from members of other groups, perhaps enemies who were killed in fights. Evidence of various death rituals, including skull cults, excarnation and other types of manipulation and deposition of human bones is known from many areas in the Mesolithic period (e.g. Gray Jones, 2011; Brinch Petersen, 2016; Sørensen, 2016; Gummesson et al., 2018). Loose human bones – manipulated or not manipulated – have been found in prehistoric settlements, which also might be an indication of the ritual use of human body parts (Brinch Petersen, 2016, Küßner, 2016).

Raw material for human bone pendants may have also been collected from old burials. It is possible that some deceased were not buried but left in the forest on wooden platforms or trees, such as is described in ethnographic research on Northern areas (e.g. Harva, 1938, Sørensen, 2016:65–67). For example, the ancient Sami of Fennoscandia deposited their deceased in forests, caves and between stones (Manker, 1961:37–53, Storå, 1971). Bones from such deposits might have been dispersed and later collected by humans.

As our results indicate, human bone artefacts from Yuzhniy Oleniy Ostrov have very poor preservation. The edges of the fracture area are visible and complete on one item. On the rest of the items, the edges have entirely eroded away or demonstrate relatively recent fragmentation and could not be analysed. In one case, the fracture angle can be characterized as variable (intermediate) (Table 3l) (Villa and Mahieu, 1991), which may indicate both its dry and fresh state at the time of breakage. The orientation of fracture of another one pendant (Table 3j) can be characterized as spiral breaks which usually occur on fresh or green bone (Fernández-Jalvo and Andrews, 2016: 284). Nevertheless, we cannot exclude impact on the bone of natural forces, not specifically directed (Ono, 2005), which could also lead to the formation of such a fracture. According to the results of the traceological analysis, both described pendants are made of fragments of the splitting of one bone (Fig. 3). After the resulting reconstruction, it became clear that the edges of the two pendants (in the upper part of the figures) form oblique angles of fractures, which are also a characteristic feature of fragmentation of green bones (Villa and Mahieu, 1991). Thus, we can conclude that some of the raw material could have had a fresh or semi-fresh state (with

Fig. 3. Reconstruction of the partial shape of the human bone before it was split (grave 113: YOO99, MAE 5716–502 and YOO93, 5716–516). Photo Anna Malyutina/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

preservation of plasticity) at the time of making pendants from it.

5.3. Evidence of cannibalism?

Cut marks, intentional breakage, unusual deposition, and polished surfaces on human bones within archaeological contexts are usually associated with cannibalism (Verna and d'Errico, 2011:145, Núñez and Lidén, 1997, Núñez 2005, Schulting et al., 2015, Brinch Petersen, 2016:55–57). Cannibalism has also been associated with fresh fractures on human bone (marrow extraction), and sometimes with constructed human bone artefacts as well. The manipulation of the bodies of the dead and use of their bones in many ways for ritual and non-ritual purposes is a widespread phenomenon in prehistory and history.

Cannibalism is often associated with other ritual treatments of human bone. Cannibalism that is associated with the making of human bone tools has been reported already in the Neanderthal occupation context at Goyet in Belgium c. 45,500 years ago (Rougier et al., 2016), and it is a recurrent feature of Magdalenian (c. 17,000–12,000 uncal BP) central and South European sites (Bello et al., 2017). In Gough's Cave in the United Kingdom (c. 12,700 cal BC), an engraved human radius also attests to cannibalistic rituals, indicating that the individual to whom the bone belonged was disarticulated and skinned and their muscles filleted (Bello et al., 2017).

Pereira (2005:300) observed cutting marks in grooved human bones that were used as rattles from prehispanic Zacapu, Michoacán in Mexico, and he demonstrated that soft tissues were separated from the bone with sharply pointed implements before designing the artefacts. In this case from Mexico, it was possible to confirm that the raw material had come from freshly deceased humans. Careful analyses of materials from other archaeological sites show that human teeth were extracted for pendants from fresh and flesh-bearing corpses, and also from living people (see, for example, Gambier, 2000, White, 2007, Haddow et al., 2019:8).

Earlier studies have associated the splinters of animal bones that have fresh breakages with refuse from marrow extraction (Binford, 1981). Fresh fractures alone cannot be used as evidence of cannibalism because, as described above, humans have also made artefacts of human bone without eating the meat. Cut marks from filleting and meat removal are usually needed for confirmation. None of the human bone pendants from Yuzhniy Oleniy Ostrov show traces of meat removal, such as cut marks. This is not necessarily the whole truth, however, since the items are small, and their original surface has been polished away in many cases (likely a result of normal wear caused by the pendants being worn by humans). It is possible that the bones had cut marks that are not visible in these small fragments. Cannibalism cannot be ruled out even though we do not have clear evidence of such.

6. Conclusions

We conclude that human and animal bone pendants were basically made and used in a similar, simple way as animal bone pendants, and for use as ornaments attached to clothes or in a necklace or bracelet, or as rattles. The fracture features identified for the two human bone pendants indicate the likely use of fresh or semi-fresh bones.

We suggest that the use of human bones in a way that was similar to how animal bones were used indicates a special attitude towards animals, ancestors and their bones. Perhaps the raw material used for making pendants was not important, and no difference was perceived for human and animal bone. Animal tooth pendants were significant cultural objects for the community or communities using the cemetery. The possibility that the bone pendants were substitutes for tooth pendants increases their symbolic value – both for pendants made from human bones and those made from animal bones. This mixing of raw materials might indicate a tradition of transformation and fluidity between things and beings.

Evidence of the use of human bone and teeth for ritual purposes and for making artefacts is a widespread phenomenon in prehistory and history. Considering the number of human bone artefacts from Yuzhniy Oleniy Ostrov, we assume that more artefacts made from human bone will be identified in many other prehistoric contexts.

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Fig. 4. The groove on one of the items has clear V-shape, indicating a use of a sharp stone tool (grave 69; YOO17; MAE 5716–268). a – microscopic traces of use in the form of polishing and linear marks (enlargement X100); b – macroscopic traces of planing/scraping (enlargement X50). Photo Anna Malyutina/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

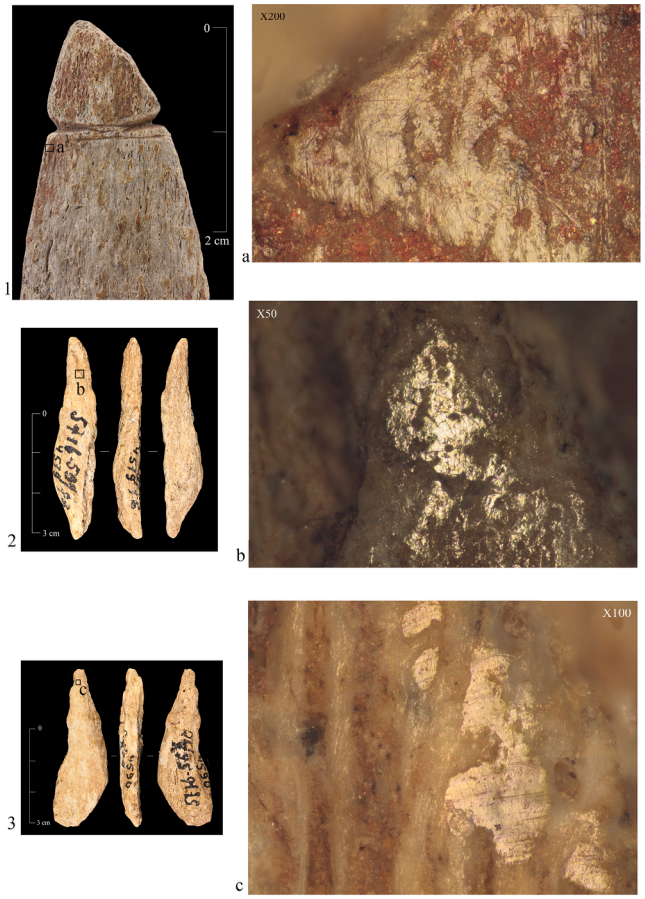

Fig. 5. Human bone pendants and microscopic traces of their use. 1 – grave 113, YOO99, MAE 5716–502; 1a – areas with polishing and irregular thin, short or long scratches on a wide face (enlargement X200); 2 – grave 113, YOO95, MAE 5716–502; 2b – microscopic traces of use in the form of polishing and linear marks (enlargement X50); 3 - grave 113, YOO98, MAE 5716–502; 3c - microscopic traces of use in the form of polishing and linear marks (enlargement X100). Photos Anna Malyutina/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

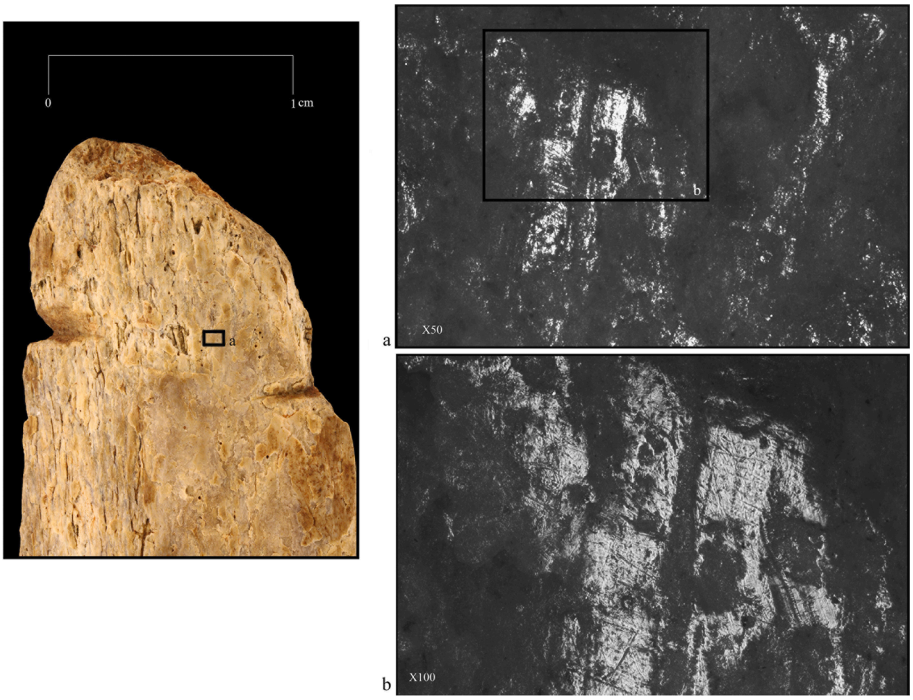

Fig. 6. Microscopic linear traces near the grooves on a human bone pendant from grave 113 (5716–516; YOO93). Enlargement a: X50; b: X100. Photos Anna Malyutina/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

Fig. 7. Pendants made of animal bones from grave 68. Photo Stas Shapiro, Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

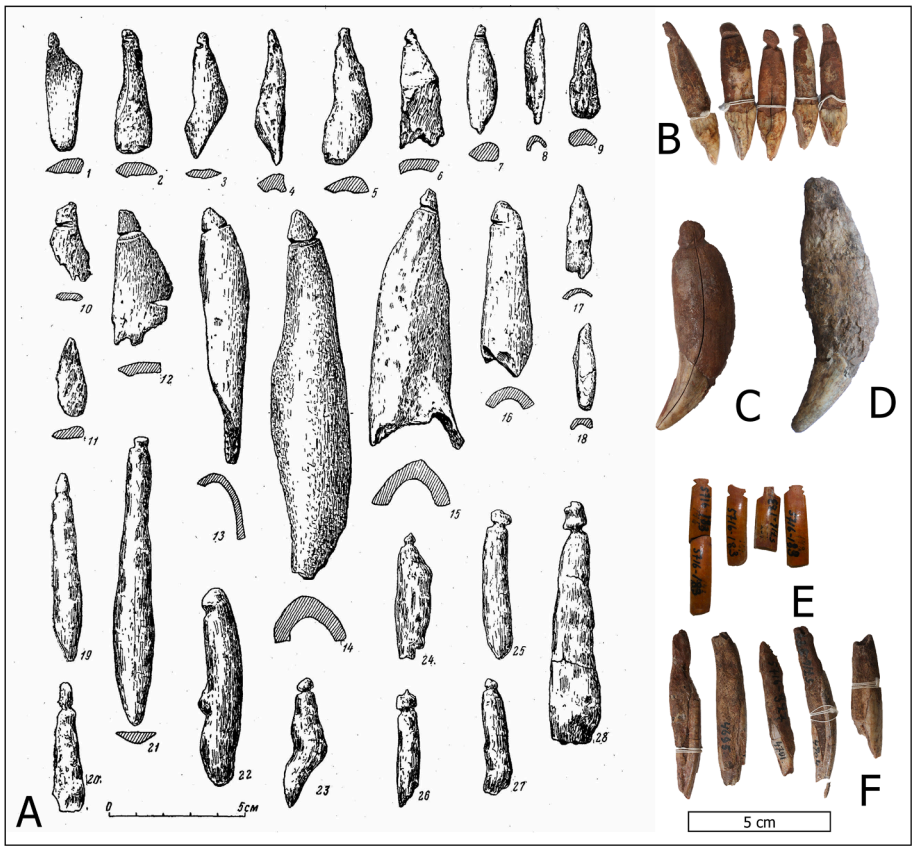

Fig. 8. A) Drawings of some bone pendants in graves at Yuzhniy Oleniy Ostrov (Gurina 1956, Fig. 85); Numbers 2, 4, 6, 7, 12, 14, and 16 (grave 113) and 24 and 26 (grave 69) are made of human bone; B–E) Animal tooth pendants from Yuzhniy Oleniy Ostrov: B) Eurasian elk (*Alces alces*) incisors MAE 5716–51 (grave 9), C) brown bear (*Ursus arctos*) maxillary dexter canine MAE 5716–82 (grave 19), D) brown bear (*Ursus arctos*) maxillary sinister canine (grave 94), E) Eurasian beaver (*Castor fiber*) incisors MAE 5716–183 (graves 55–57), F) wild boar (*Sus scrofa*) incisors MAE 5716–527, 529 (grave 114). Photos Kristiina Mannermaa/Peter the Great Museum of Anthropology and Ethnography, Kunstkamera, St. Petersburg.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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