

A case of Avar period trepanation from Croatia

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ABSTRACT: The Avar period cemetery of Nuštar, situated in continental Croatia, is dated to the 8th and the beginning of the 9th century. Rescue archaeological excavation yielded 196 burials. During analysis of human skeletal remains, an individual with a large cranial lesion caused by trepanation was found. Trepanation is a surgical procedure performed on the skull in order to remove a fragment of the bone using a sharp instrument or drill. It has been practiced in various regions since the prehistoric period for both medical and ritual reasons. The aim of this paper is to provide a description of the observed lesion based on macroscopic appearance accompanied by radiography, computed tomography scanning and 3D optical scanning. Furthermore, possible cause and employed technique are taken into consideration, as well as cultural and historical implications of the case.

KEY WORDS: cranial lesion, surgery, skeletal remains, Nuštar, Early Medieval period

Introduction

The site of Nuštar is situated in continental Croatia (Fig. 1). It was discovered by accident in 2011 during construction works for a new football field. A rescue archaeological excavation was carried out later that year, when a mediaeval cemetery from the Late Avar period (710–830 AD) was partly excavated.

The cemetery was only partially explored, leaving the southern and eastern borders undefined. The excavated area was 140 m × 100 m, with graves concentrated in the south-east section measuring about 60 m × 40 m. Ten fairly regular burial rows with a total of 196 graves

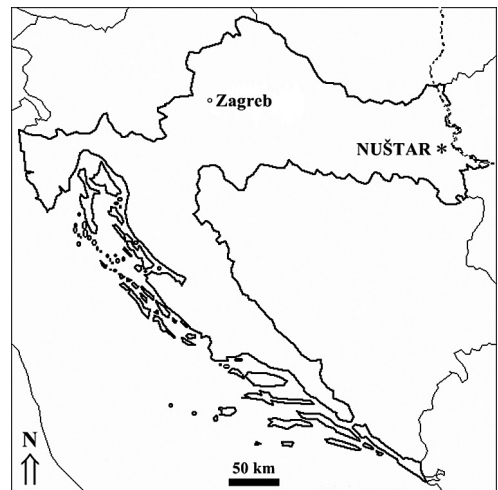


Fig. 1. Map of Croatia with the location of Nuštar cemetery

were excavated. Most of them were rectangular in shape, with three major types of grave pits. In the vast majority of graves remains of wooden structures were observed. All burials were oriented west-east, while smaller deviations (up to 15°) to north or south were recorded. Most of them were single inhumations, with only seven multiple burials present. The deceased were buried in a supine position on their back, with arms laid next to the body.

Over 1500 finds, most of them in very good condition, were discovered in 175 graves. Two main categories of grave finds can be distinguished: traces of food offerings (pottery, wooden vessels and animal bones) and grave goods (dress and personal ornaments, tools and weapons). In general, grave finds from Nuštar belong to a society which could be referred to as higher middle class.

The most common finds were pottery vessels and iron knives. Male graves often had decorative bronze belt sets (but also simple, everyday belts) and female graves usually had some kind of jewellery (earrings, necklace beads, bracelets, and fingerings) or tools (needle cases, spindle whorls). Burials of children had finds very similar to adult graves, suggesting that in the Nuštar community age of the deceased was not associated with differences in mortuary practices. Finds from Nuštar can be easily connected to the Avar period cemeteries from Hungary, Serbia, Slovakia and Austria (Szentpéteri 2002).

Based on grave finds (belt sets, jewellery, tools and pottery) most burials belong to the Late Avar period, but it is possible that some of them belong to the Middle Avar period. In terms of absolute chronology we can define this time period throughout the 8th and beginning of the

9th century. Together with a number of other sites in the area of today's Croatia and Serbia, along the rivers Sava, Danube and Tisza, the Nuštar site fits into a hypothetical southern and south-eastern border of the Avar Khaganate from the late 7th to the end of 8th century (Garam 1987; Filipec 2003).

From the year 568 until Charlemagne's Avar wars (788–803), the riders of the steppes dominated the Carpathian Basin and its environs (Daim 2003). Parts of what today are Austria, Hungary, Slovakia, Czech Republic, Romania, Serbia and Croatia, were at some point integrated into Avar Khaganate. In these regions different elements of culture, ethnicity and social structures, belonging to indigenous, Germanic, Slavic and nomadic (steppe) populations, mixed. Such multi-regional, multi-ethnic and time related mixture resulted in different aspects of Avar period cultural remains, particularly seen in the assimilation of external influences. The early period material culture (568–690), strongly influenced by the Byzantine Empire, is recognisable in metal objects made by pressing. The late period material culture (690–830), often called griffin-tendrill horizon (due to mostly used motifs), is recognisable in metal objects made by casting. Unfortunately, contemporary written sources do not provide enough information about the Avar state, society, ethnicity and economy, or the everyday life. Most of the data are obtained from more than 60,000 excavated Avar period graves (more about this subject in Vida 2008).

Material and methods

Anthropological analysis of human skeletal remains from Nuštar revealed the

presence of an isolated skull with a large cranial lesion, specifically an opening created by trepanation. The cranium could not be associated with any particular grave, but most likely it comes from graves disturbed during construction works before the rescue excavation started. However, there is no doubt about its provenance, given that direct radiocarbon date of 7th to 8th century was provided from a sample of the right zygomatic bone. The calibrated 1 SD range is 684–722 AD and 740–767 AD (UBA–25620: 1277±29 y BP). Sex and age estimation, based on morphological characteristics of the skull, cranial suture closure and dental status, showed that this individual was a male aged over 50 years at the time of death (Buikstra and Ubelaker 1994).

In this work, we provide a description of the cranial lesion, as well as discuss its possible cause and employed technique. In order to analyse the lesion in detail, we use several different methods: macroscopic observation, radiography, computed tomography (CT) and 3D optical scanning. Also, we consider the cultural and historical implications of the case by

putting it into a wider geographical and temporal context.

Results

The cranium was very well preserved with all the bones, apart from the zygomatic arches, present. Also, fragment of the right zygomatic bone was sampled by sawing for radiocarbon dating. Slight postmortem damage to the outer surface was observed in varying degrees on all cranial bones. Several Pacchionian depressions, visible as pits with sharply defined margins, were present on endocranial surface of both parietal bones along the sagittal suture. A circular bony protuberance was visible on ectocranial surface of the left parietal bone, adjacent to the sagittal suture, measuring 15.4 mm×13.2 mm. The observed Pacchionian depressions and bony protuberance represent normal variants of cranial morphology. No teeth were present in the maxilla due to antemortem loss. Alveoli were almost completely resorbed.

The lesion was located on the left parietal bone, oriented in the anteroposterior direction (Fig. 2). Both outer and in-



Fig. 2. Photograph of the trepanned cranium. (a) Lateral view of the cranium. (b) Close-up view of the perforation. Photograph by P Rajić Šikanjić

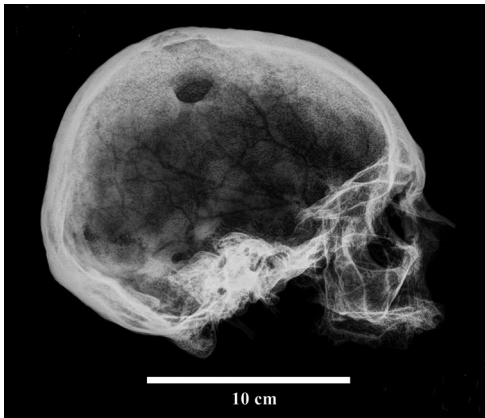


Fig. 3. Radiograph of the cranium

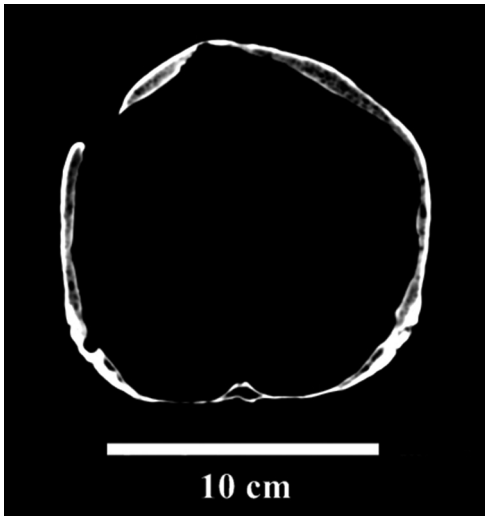


Fig. 4. CT image of the cranium

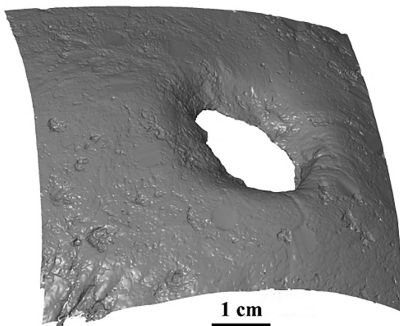


Fig. 5. 3D scan of the perforation

ner table of the bone had been removed, creating a perforation in the skull. The perforation has a slightly irregular oval shape with dimensions 21.2 mm (anterior-posterior) and 11.8 mm (medial-lateral). Entire edge of the perforation is irregular with bony spicules. The outer margins of the lesion have remodelled edges, with only a small section being rounded while the rest is funnel shaped with linear cuts pointing toward the perforation. The area closely surrounding the lesion does not exhibit any signs of trauma or inflammatory reaction.

Following the visual examination, radiography, CT scanning and 3D scanning were carried out (Fig. 3, Fig. 4, Fig. 5). As anticipated, the opening was clearly visible by all methods. Also, its oval shape and dimensions were confirmed. The surrounding bone showed normal structure. Compact bone was present only on the edge of the lesion, while its well-defined margins exhibited clear image of bone regeneration and complete healing of the wound. No evidence of irregular new bone formation or infection was observed.

Trepanation: the oldest cranial surgery

Trepanation is a surgical procedure performed on the skull in order to remove a fragment of the bone using a sharp instrument or drill. The operation involves incision of the scalp, cutting through the soft tissue and removal of the bone (Roberts and Manchester 2005). This results in the exposure of the membranes covering the brain.

This procedure has been carried out since the prehistoric period, confirmed by historic written sources as well as skeletal remains of archaeological pop-

ulations (Roberts 2000). The earliest description is provided by Hippocratic writings in the 5th century BC (Ortner 2003). Although writings are an invaluable source of information, skeletal remains are indispensable as they present direct evidence of these procedures enabling us to study them in detail. Ancient examples can be found throughout the world and their numbers are in thousands. In Europe this practice has been confirmed since the Mesolithic period by a find from a Ukrainian site (Lillie 2003). During this time span, it appeared in different geographic regions and cultures. Its use declined during the mediaeval period (Germanà and Fornaciari 1992). However, ethnographic accounts confirm the existence of this practice as late as the end of the 19th century in the central Balkans, specifically Serbia, Montenegro and Albania (Mikić 2006).

From present perspective it can only be speculated to the reason of trepanation cases in the past. Although in the literature various motives are discussed, for the purpose of this paper they are grouped into two broad categories: surgical and ritual (Lisowski 1967; Aufderheide and Rodríguez-Martín 2003; Ortner 2003; Roberts and Manchester 2005). Surgical trepanations were performed as specific response to a medical issue, such as trauma, infection or tumour. They can sometimes be clearly identified in the skeletal material exhibiting specific bone reactions. Reasons for ritual trepanations are twofold. Firstly, they were carried out in an attempt to deal with apparently unexplainable and mysterious physical conditions (such as headache, vertigo, neuralgia, and coma). As these illnesses leave no skeletal signs, they are impossible to confirm in human remains. Secondly, they could have been performed

as part of ritual practice of specific societies. These examples are the hardest to interpret as their motive is culturally determined.

Regarding the methods employed, several can be found on skeletal remains from archaeological context (Campillo 2007). The most common techniques are grooving and scraping (Ortner 2003; López et al. 2011). Grooving involves drilling the skull with a sharp and hard instrument in turns and repeatedly drawing a groove until a perforation is created. Cone-shaped, circular perforation has vertical or steeply bevelled edges. Scraping involves a sharp-edged instrument which is repeatedly scraped over bone surface until the perforation is complete. The perforation is oval or circular and surrounded by broad and shallow bevelled edges.

Trepanation, as any other surgical procedure, carries some risk for the patient. This was especially significant in the past, when anatomical knowledge as well as hygienic standards were limited. When at the end of the nineteenth century modern antisepsis and prophylaxis of infection were introduced, accompanied by the increased understanding of the importance of intracerebral pressure in head injury, the outcome of trepanation became less unpredictable for the patient (Gross 2003). Before this time, death could have occurred either during operation or later from complications. Despite this, there are numerous examples of survival, even long-time, in the archaeological populations from different periods and regions (Roberts and Manchester 2005).

Medical implications of the case

Detailed analysis of the Nuštar cranium exhibiting an oval shaped perforation on

the left parietal bone confirmed that the lesion resulted from trepanation. Careful examination excluded all other possible causes, such as infectious diseases, tumours and congenital defects (Ortner 2003).

The side and location of the observed lesion are consistent with the majority of archaeological cases. Most of them, as well as the Nuštar case, are found on the left frontal and parietal bones and only rarely on the occipital bone. The possible explanation is a right-handed surgeon or a right-handed attacker (Aufderheide and Rodríguez-Martín 2003).

Morphological characteristics of the observed lesion suggest that the employed technique was scraping. This is a method that involves fine cutting movements with a sharp-edged instrument over the bone until the perforation appears (Roberts and Manchester 2005). In this case, scraping is confirmed by the bevelled edges and linear cuts surrounding the perforation. Scraping is the most widely used method and one that enables maximum control during the bone cutting, thus involving the lowest risk of damaging the brain (Ortner 2003).

Even though scraping was the applied method, it can only be speculated about the instrument used to perform this procedure. Currently we may hypothesize that the observed trepanation was carried out by a knife or a similar sharp-edged tool. Analysis of grave finds from the Nuštar cemetery attested to the presence of such objects in everyday life of the community. The iron knife is one of the most frequent grave finds, with a total of 107 knives of different length. They were discovered in graves of males, females as well as children, usually situated by the upper leg. The most common form is single-edged knife with straight

back (Fig. 6). In the published literature there is no consensus about instruments used in these procedures. Krasilnikov and Ruzhenko (1981) interpret the finds of a silver template and two knives as tools used for trepanation in their paper describing the “burial of the surgeon” from an Early Mediaeval Bulgarian site. They associate these tools with a case of trepanation carried out by cutting from the same cemetery.

Macroscopic characteristics of the lesion were supported by radiography, CT and 3D scanning. Bone remodelling and rounded margins indicate healing of the bone and consequently survival of the patient. Different studies report survival rates ranging from 75% to as high as 90% of the patients (Bennike 1985; Campillo 2007; Andrushko and Verano 2008). The absence of bone response on endocranial and ectocranial surfaces indicates there were no post-operative complications such as infections. The abovementioned analyses did not determine the precise medical cause for the trepanation, as no pathological changes were detected by any of the applied methods.

It is difficult to determine when this procedure was carried out on the examined individual. The characteristics of the lesion suggest that this was a long-term process of healing. Weber and Wahl state that the process of bone healing obliterates any cut-marks resulting from the operation after one or two years (Weber and Wahl 2006). Additionally, Nerlich et al. (2003) showed that more or less extensive signs of ‘healing’ occur after more than 4 years since the operation. In these cases, margins of the lesion appeared considerably altered with significant smoothing and rounding.

It can be argued that several factors contributed to the success of trepana-

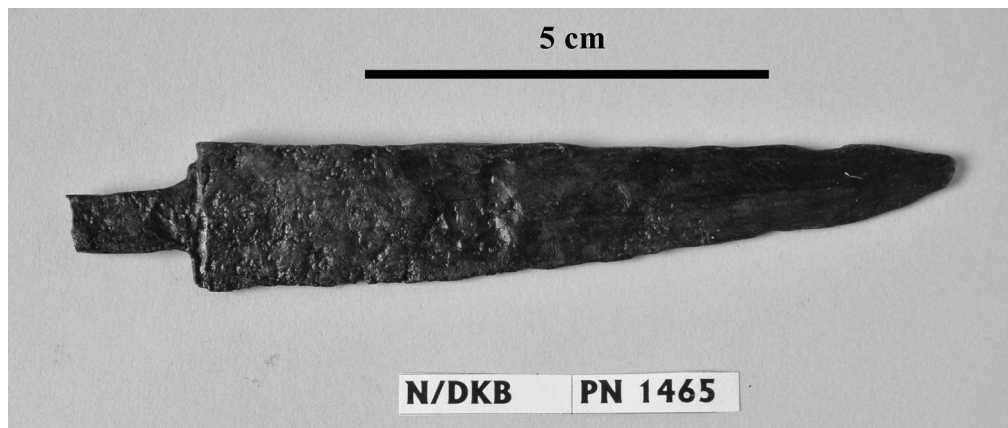


Fig. 6. Example of a knife from the cemetery of Nuštar. Photograph by J Škugor, Croatian Conservation Institute

tion. Survival of such a complicated surgery required a skilled and experienced surgeon with basic knowledge of human anatomy. A trepanation may be complicated by damage to the blood vessels, meninges and brain that can be potentially fatal for the patient (Weber and Wahl 2006). Also, postoperative care had to be included in the recovery of the patient in order to avoid possible infection (Han and Chen 2007). A significant number of healed trepanations from various periods and regions confirm presence of a certain anatomical and medical knowledge, followed by successful recovery treatments.

Historical context

Currently only two cases of trepanation on archaeological skeletal material from Croatia have been published. The first was the Bronze Age skull of a female aged 20 to 40 years discovered at the Bezdanjača cave site (Malez and Nikolić 1975). The oval lesion was located on the right side of the frontal bone. Characteristics of the lesion suggest that this female survived the procedure for a significant period of time (Malez and Nikolić 1975).

The second was the 5th century AD skeleton of a male aged between 51 and 55 years from the site of Ludbreg (Novak et al. 2013). The oval shaped lesion was located on the left side of the frontal bone and the left parietal bone and perforated all bone layers. It was most probably performed by scraping as therapy for head injury. Degree of healing indicates long term survival of this individual (Novak et al. 2013).

All three Croatian trepanations are isolated cases according to time period and geographic distribution. There is also a significant time span between them. Consequently, there cannot be any claim to the tradition of trepanation in this region.

As the Nuštar case is from the Avar period, it needs to be put in context regarding other Avar finds. Currently there are over 600 known graves from several Avar cemeteries in Croatia¹. However,

¹ Bijelo Brdo I – 66 graves (Ivaniček 1949); Brodski Drenovac – 32 graves (Vinski-Gasparini and Ercegović 1958); Otok-Gradina – 22 graves (Težak-Gregl and Šmalcelj 1992); Privlaka-Gole njive – 230 graves (Šmalcelj 1981); Stari Jankovci-Gatina – 88 graves (Šmalcelj

Table 1. Cases of trepanation from Avar period sites.

Site	Individuals	Age (years)	Healing	Location	Type	Reference
Szeged – Kiskundorozsma – Kettőshatár	3 juveniles	8–11	yes	left side of the coronal suture	surgical	Bereczki et al. 2010
		2–3	yes	right parietal	surgical	
		11–13	no	right frontal	surgical	
Bélmegyer – Csömökidomb	male	40–45	yes	four defects	surgical	Bereczki et al. 2015
Baracs – Szitányidűlő	juvenile	7–9	yes	right parietal	surgical	László 2016
Ellend	female	20–22	yes	–	–	
Keszthely – Dobogó	male	40–45	no	–	–	
Keszthely – Fenékpuszta	female	20–22	no	frontal	–	
Kiskőrös	male	55–60	yes	two defects	–	
	male	–	–	–	–	
	male	–	–	–	–	
Nagykamarás	male	50–55	yes	frontal	–	Józsa/Fóthi 2007
Pókaszeptek	male	–	yes	frontal	–	
Szeged – Fehértó	male	60–65	yes	temporal	surgical	
Szeged – Kundomb	male	45–50	yes	frontal	surgical	
Toponár – Sántos	female	–	–	–	–	
Vedresháza	male	60–65	no	right parietal and occipital	–	
Kékesd	female	–	yes	left parietal	possible case	Wenger 1968

er, comparison with other Avar skeletal samples offers a different picture. Over 60,000 graves are known in the region of the Carpathian Basin that was under the Avar rule (Daim 2003). Among these, 18 cases of trepanation have been published (Table 1) (Garam 1975; Kovrig 1975; Józsa and Fóthi 2007; Bereczki et al. 2010; Bereczki et al. 2015; László 2016). The observed cases are from 14 sites located on the territory of present day Hungary. Even though data is not available for each case, certain conclusions can be

reached. The procedure was most often performed on males, with only several cases of females and juveniles. A large part of trepanations were successful, as confirmed by signs of healing. The defect was most commonly located on the frontal and parietal bones. The majority of them are of unknown type; however, several cases of surgical trepanations were observed.

There is an obvious disproportion in frequency of trepanation cases found on the Avar territory. Considering the approximate abovementioned numbers, there is only 0.002% of trepanations in the Croatian sample, compared to 0.03% in the Carpathian sample. It is interesting to note that all of the Carpathian examples come from the territory of southern Hungary and presently the Nuštar case is

1992); Nuštar – 196 graves; Velika Gorica – 5 graves (Simoni 1981); Zagreb-Kruga – 4 graves (Simoni 1981); Novo Čiče – 2 graves (Simoni 1981). Also, not to be neglected, numerous stray finds which most likely originate from destroyed graves (for most recent list see Filipec 2003).

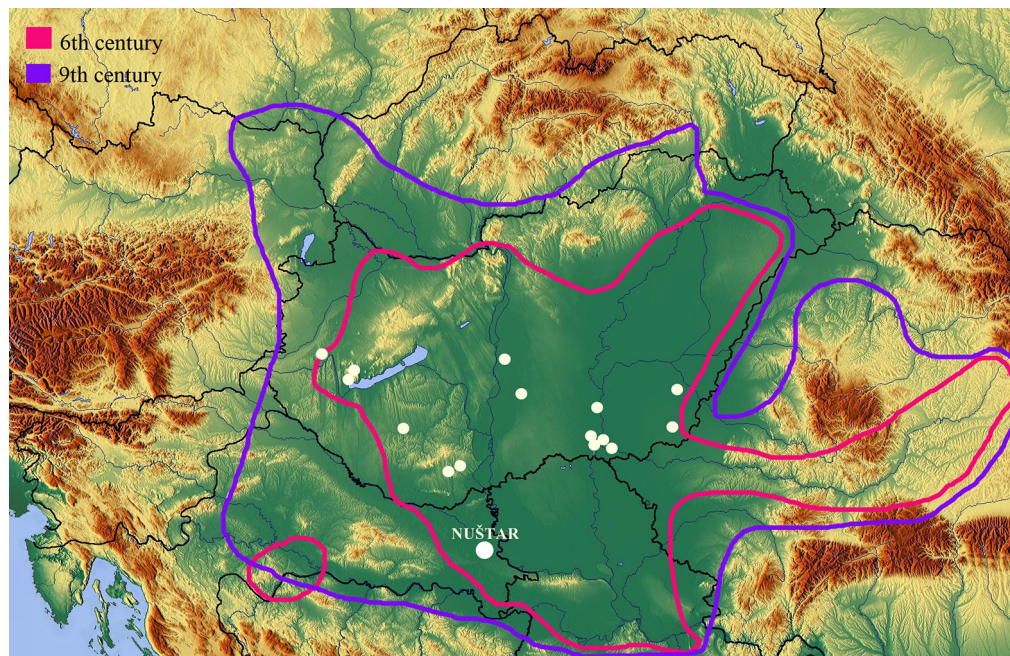


Fig. 7. Map of Avar territory with marked trepanation cases

the only exception (Fig. 7). Additionally, it needs to be noted that the previously mentioned area is the southern region of the Avar territory. In this context and bearing in mind the proximity of southern Hungary and Croatia that in the Avar period formed the southern border areas, we offer two tentative explanations for our example. The first one, based on the geographical distribution of cases, is that the practice of trepanation was a well known procedure in this part of Avar territory. It could have spread by transfer of knowledge or visits by travelling 'surgeons'. The second one is that the procedure on the individual from Nuštar was not performed locally, but somewhere on the territory of southern Hungary.

Relatively large number of Avar trepanations, especially successful ones, is the evidence to medical knowledge of these communities. Additional proof is the

presence of cranial trauma on some of the trepanned skulls, leading to the conclusion that there was an understanding of treatment of injuries and diseases. As an indication for Avar period trepanations, both surgical and ritual reasons must be considered. Trepanations were performed in both sexes and all age groups, with the majority of the affected individuals being adult males.

Conclusion

This paper reports the third archaeological example of trepanation from Croatia that is also the first case from an Avar period skeletal sample.

The procedure was carried out on the left parietal bone of a male aged over 50 years excavated at the cemetery in Nuštar. The observed features of this case are in accordance with other published cases of

Avar trepanations. This refers to the sex and age of the individual, as well as position and characteristics of the lesion and the employed procedure. Morphological features of the lesion suggest that the procedure was performed by scraping. The amount of healing and the extent of bone remodeling clearly indicate that the patient survived the operation and lived afterwards for a significant period of time. Since there are no pathological changes that would presumably require treatment visible on the skull, based on present paleopathological findings it appears that there is no clear medical indication for trepanation. However, sex and age of the individual as well as location of the defect may suggest cranial trauma caused by a right-handed attacker.

Comparison with other Avar period trepanations offered interesting insights. Geographic distribution showed that all of the cases come from the territory of southern Hungary and currently the Nuštar case presents the only exception. Even though Nuštar is part of modern Croatia, during the Avar period this area was on the southern border of the Avar territory.

We offered two possible explanations for presence of this isolated case from Croatia. Both of them testify to the fact that there was communication and exchange of ideas and knowledge between Avar period communities.

Authors' Contributions

ZP and PRŠ performed the anthropological analysis and interpretation of obtained data, ARP provided archaeological and historical context of the find. All authors participated in drafting and revising the manuscript.

Conflict of interest

The Authors declare that there is no conflict of interests.

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