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SKELETAL EVIDENCE OF TREPANNING ON A 5th CENTURY SKULL FROM LUDBREG, CROATIA

KOŠTANI DOKAZ O TREPANACIJI NA LUBANJI IZ V. STOLJEĆA IZ LUDBREGA

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Summary

This paper presents a case of skull trepanation from the town of Ludbreg in north-western Croatia. This is the second case of trepanation reported in human skeletal remains from archaeological sites in Croatia. The procedure was performed on an adult male buried in a tomb under tegulae *at the "Somođi Garden" site. The archaeological context and radiocarbon analysis date the bone sample to the 5th century AD, i.e. to the Migration Period. The trepanned aperture is located on the left side of the frontal bone and the left parietal bone. The lesion is oval in shape with all three layers of the* calvarium *breached, leaving dura mater exposed. This neurosurgical intervention was most probably performed by scraping for therapeutic reasons (head injury). The morphology of the lesion strongly indicates that the individual survived the operation and lived for a longer period of time, several years at least.*

Key words: *skull trepanation; anthropological analysis; scraping technique; 5th century, Ludbreg, Croatia*

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Introduction

Trepanation or surgical removal of a portion of the cranium is probably the most remarkable trauma observed in human skeletal remains from archaeological sites. The term is derived from the Greek τρυπανον (trepanon), meaning auger or borer, i.e. instrument used for drilling and opening the skull. According to Aufderheide and Rodríguez-Martín [1], the procedure involves creating a defect in the skull vault to open a communication between the cranial cavity and the environment, whose success depends on avoiding injury to the meninges, brain, and blood vessels.

The earliest skeletal evidence of trepanation probably dates to the Mesolithic [2-4] and certainly to the early Neolithic Period [1,5-7]. Prioreschi [8] estimated that between 6% and 10% of excavated Neolithic skulls from Europe have been trepanned. Fewer examples are present from the European post-Neolithic sites, possibly due to the popularity of cremation during the late Bronze Age and the La Tene Period [9]. During the late Antiquity and the early Middle Ages, trepanation was more frequent, especially in central Europe [10-22]. The practice declined in Europe after the expansion of Islam and disappeared during the High Middle Ages [23]. Trepanation was practiced all over the world and has been documented in skeletal remains from almost every continent, with the highest frequency in South America and Europe [24].

The earliest written records of trepanation come from the Hippocratic texts entitled "Places in man" and "On head wounds", which describe particular types of skull fractures that required surgical intervention, trepanning in particular [25,26]. Galen, probably the most famous Roman physician, agreed that some skull fractures required therapeutic trepanation in order to relieve pressure [27]. While head injury was frequently cited as an indication for trepanation by a number of Graeco-Roman authors, other indications included epilepsy, headache, and paralysis [25,26].

As the oldest trepanation dates back to at least the early Neolithic, i.e. before the widespread use of metals, the instruments used had to be made of stone, most probably flint or obsidian. The Hippocratic writings describe some of the instruments used in trepanation: the earliest texts mention a crown saw, which is basically a metal cylinder with teeth on one end, while later texts describe a much more advanced small saw, clearly a type of Hey's saw [28]. Galen and Celsus also mention two types of instruments employed to remove bone and relieve pressure: a crown *trephine* for bone excision and

relief of pressure in small wounds and a drill *trepanon*, which possessed a toothed bit and was used for larger wounds [27]. Although the Graeco-Roman texts provide a relatively comprehensive description of trepanation instruments and their use, archaeological examples are surprisingly rare. Probably the best known is the trepanation kit found in a tomb of a Roman surgeon in Bingen in Germany from the 2nd century AD [29,30], that, among other medical instruments, contained metal crown saws. Parts of trepanation instruments similar to those from Bingen were also found in the surgeon's house in Rimini [31]. A somewhat more sophisticated, but poorly preserved trepanation instrument was found in the Avar grave in Mezóband, Hungary [32].

Given the numerous examples of trepanation from the territories surrounding present-day Croatia, as well as the comprehensive descriptions of the procedure and the instruments used, it is difficult to explain the lack of interest of Croatian researchers for this topic. So far, the only published case of trepanation in Croatia refers to a small trepanned aperture on the frontal bone of a cranium 39/a (adult male) from the Bronze Age necropolis in the Bezdanjača cave [33].

This paper presents a case of skull trepanation from Ludbreg in north-western Croatia dated to the Migration Period. We discuss possible reasons for this procedure, the technique and instruments used, possible use of anaesthetics, and the possibility of surviving such complicated operations.

Material and methods

Ludbreg is a town in north-western Croatia, located approximately 80 km north of Zagreb, near the Drava River (Fig. 1). It is the location of a Roman settlement of *Iovia-Botivo*, founded in the 1st century AD. It was situated on an important route that ran along the Drava, connecting Pannonia's major provincial centres *Poetovio* (Ptuj) and *Mursa* (Osijek). After several centuries of prosperity, *Iovia* was most likely destroyed during the invasion of the Goths in the late 4th century AD. The tradition of urban life was not abandoned; instead, this Pannonian settlement has existed in continuity until today.

Archaeological excavations (2008-2011, conducted by Dr Tajana Pleše from the Croatian Conservation Institute) in the very heart of the present-day town of Ludbreg ("Somođi Garden") are a continuation of systematic test digs (1968-1979) conducted by the Archaeological Museum in Zagreb. The results of this pioneering work have made it possible to glean the general

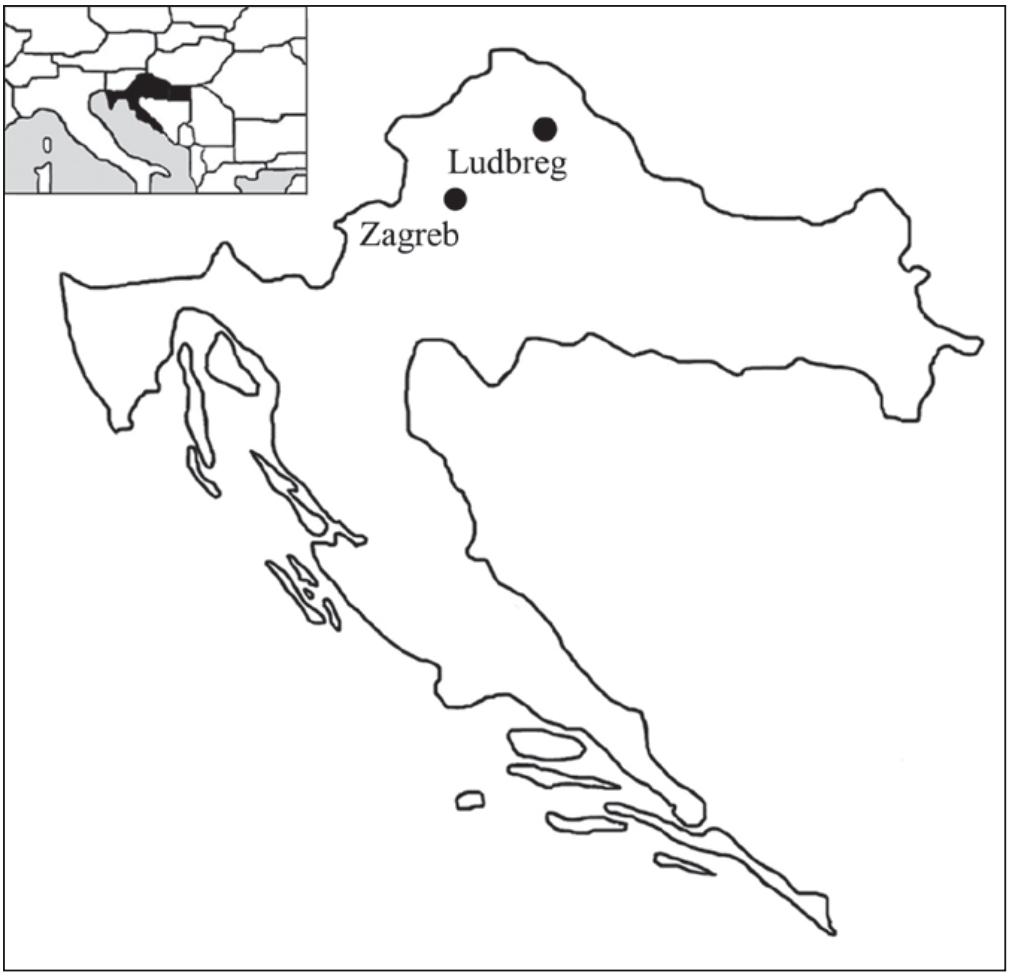

Figure 1. The geographical location of Ludbreg.

Slika 1. Zemljopisni položaj Ludbrega

urban layout of Roman *Iovia*. All of the discovered architectural structures may be dated from the 2nd to the 4th century AD [34].

During the four seasons of excavations, a large portion of Roman architecture was discovered in the "Somođi Garden". In the south-east part of the site, a small *balnea* was discovered. The Iovian baths belong to a group of smaller city baths, widespread throughout the Empire. Built as compact, un-partitioned buildings (*Blocktyp*), they fulfilled the rules of economical and structural efficiency. On the northern side of the baths, a large part of a sizeable building with portico was discovered. The building was defined on its western part with a colonnaded portico, through which one could enter a wide space divided into five rectangular rooms. On the eastern side the building was organised around a square courtyard, defined by corridors and

adjacent wings. Both buildings were remodelled during several construction phases, clearly indicating a long period of usage [35]. In the easternmost, fifth room of the southern corridor an inhumation burial (G 001/2011) in a tomb under *tegulae* (roof tiles) was discovered (Fig. 2). The tomb contained skeletal remains of one individual. A small, silver belt buckle was the only artefact found in the tomb - according to its stylistic features it may be dated to the 5thcentury AD, i.e. to the Migration period. A comprehensive analysis of the tomb and the silver belt buckle will be a subject of a separate paper which is in preparation.

Radiocarbon analysis of a human bone sample, conducted at the Beta Analytic laboratories in Miami, USA, dates the skeleton between 390 and 540 AD (2 Sigma, 95% probability), and 410 and 430 AD (1 Sigma, 68% probability).

A comprehensive anthropological analysis of skeletal and dental remains belonging to the individual buried in the described grave was conducted at the osteological laboratory of the Anthropological Centre of the Croatian Academy of Sciences and Arts in Zagreb. The sex and the age at death of the analysed individual were determined using methods described by Buikstra and Ubelaker [36]. All observed pathologies were recorded according to criteria described by Ortner [37].

Continuous CT axial slices were obtained at the Department of Diagnostic and Interventional Radiology, University Hospital Dubrava in Zagreb, using an MDCT scanner (Sensation 16; Siemens AG Medical Solutions, Erlangen, Germany) with 16 x 0.75 collimation and 0.7 mm-reconstruction increment. Scanning parameters were 300 mA and 120 kV. "Soft" (30) and "sharp" (70) kernel reconstruction algorithms were used. Three-dimensional reconstruction with OsiriX Imaging Software (Pixmeo, Geneva, Switzerland) included multiplanar reformatting (MPR), maximum intensity projection (MIP) reconstruction, and volume rendering technique (VRT).

Results

The skeleton was well preserved and belonged to an adult male, aged between 51 and 55 years at the time of death. The cranium and the mandible were complete, while some postcranial elements were missing (Fig. 3). The cranium had a roughly oval-shaped defect located on the left side of the coronal suture; approximately two thirds of the lesion was located on the left parietal bone and one third on the frontal bone (Fig. on cover page). The

Figure 2.
Grave 1 after excavation.

Slika 2.
Grob 1. nakon iskopavanja

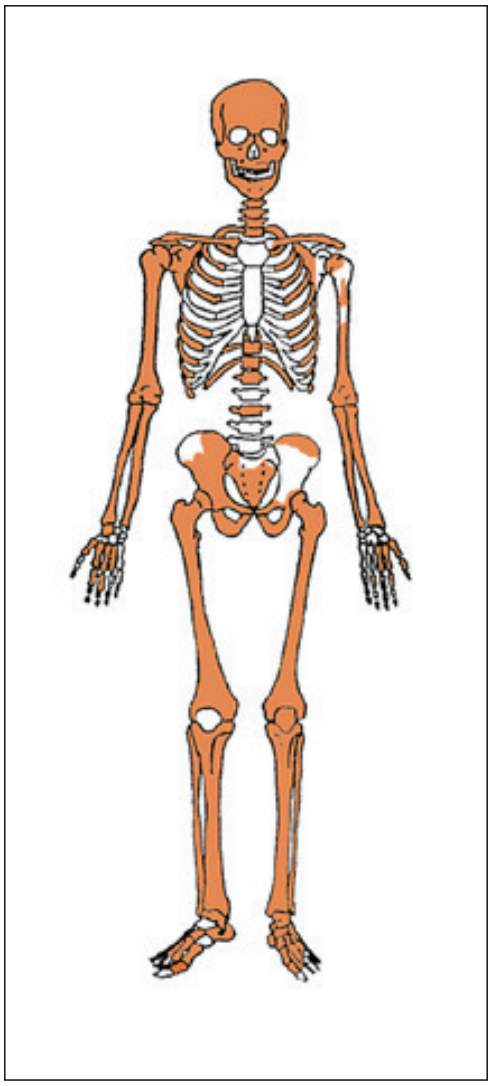

Figure 3. Inventory of the preserved skeletal elements.

Slika 3. Inventar sačuvanih koštanih elemenata

external diameter (ectocranial side) of the defect is 43x31 mm, while the internal diameter (endocranial side) is 29x19 mm. All three layers of the calvarium were breached, and dura mater was most certainly exposed during the operation (Fig. 4). The edges in all sections of the defect sloped gently towards the opening (Fig. 5). Obvious signs of healing were present; the edges around the opening were smooth, remodelled, and of uniform thickness, while the diploë was not visible (Fig. 6). No signs of infection were present on either the endocranial or ectocranial side.

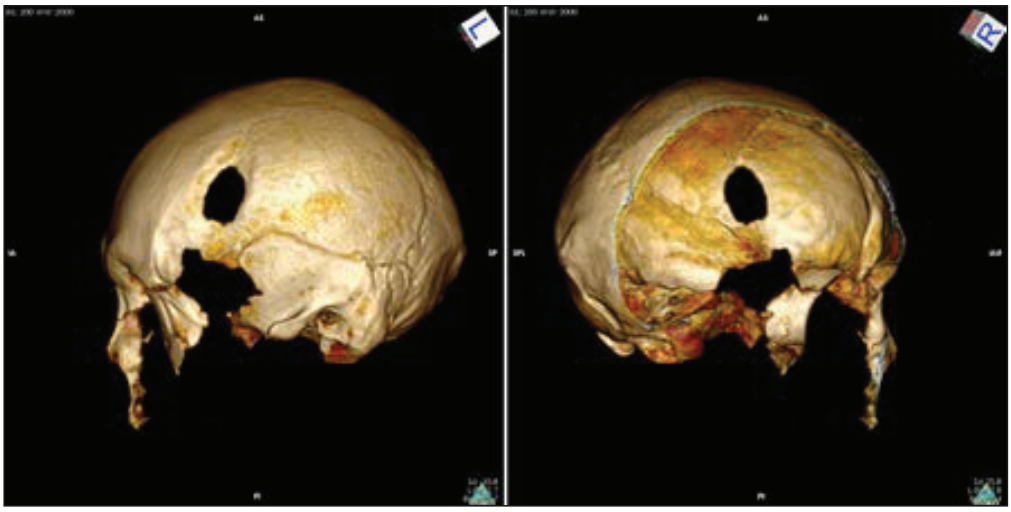

Figure 4. CT scan of the cranium. View of the trepanned aperture from the ectocranial and endocranial side.

Slika 4. CT snimak lubanje. Pogled na trepanacijski otvor s ektokranijalne i endokranijalne strane.

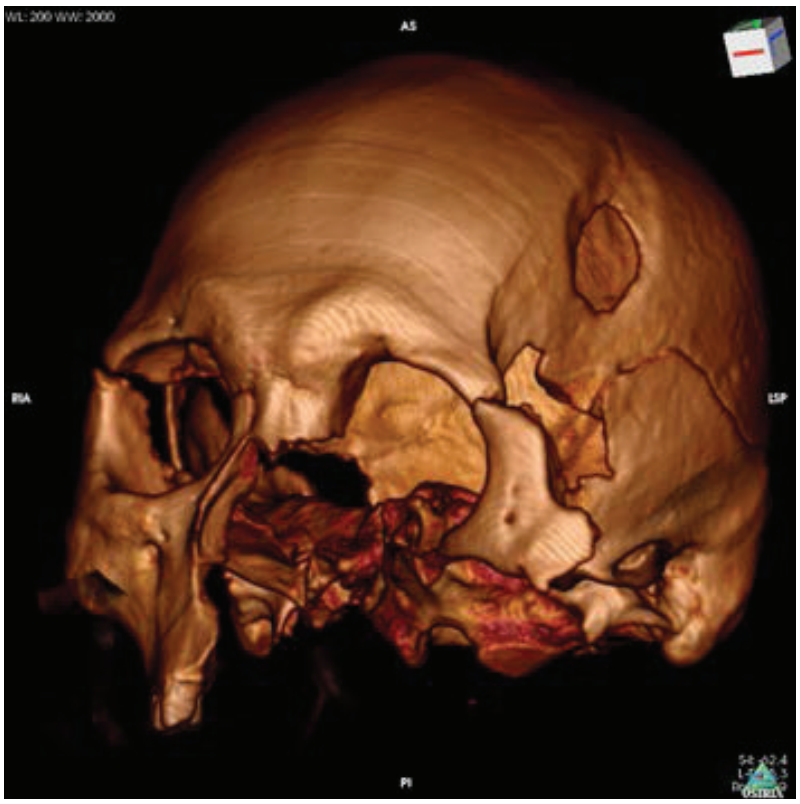

Figure 5. CT scan of the cranium - antero-lateral view. The edges have a broad shallow bevel, which is typical of the scraping technique.

Slika 5. CT snimak lubanje - anterolateralni pogled. Rubovi su široki s malim nagibom, što je tipično za tehniku struganja.

Figure 6. Close-up of the trepanned aperture. The edges are smooth and remodelled, while the diploë is not visible.

Slika 6. Uvećana slika trepanacijskog otvora. Rubovi su glatki i remodelirani, a središnji porozni dio kosti (diploë) nije vidljiv.

Beside the trepanation, the analysed skeleton showed a slight degenerative osteoarthritis on the shoulders, elbows, hips, knees, and several vertebrae, a Schmorl's node on T8, and dental enamel hypoplasia on the maxillary central incisors.

Discussion

The first question that arises from the trepanation in Ludbreg is what might have led to this complicated operation. Lisowski [9] proposed three groups of reasons for trepanning in past populations:

1 – therapeutic reasons - intended for relieving cerebral pressure and treating head injuries, including fractures and scalp wounds;

2 – a combination of therapeutic and magic reasons - treating of headaches, neuralgia or epilepsy which may have been regarded as a consequence of possession by evil spirits; and

3 – magic/ritual reasons.

The last reason would have been likely if there had been clear signs that the procedure had been carried out *post mortem* (absence of healing, no visible pathological signs that would justify trepanation). According to

some authors [9,17,37], ritual interventions were not uncommon, and were usually done to obtain rondelles (round bone discs cut from the edge of a trepanation defect with a central hole for a purpose of suspension) or bone powder for healing potions or as magical amulets. Since the Ludbreg trepanation shows clear signs of healing, the procedure was definitely conducted *ante mortem*, which excludes magic/ritual reasons. As in this particular case there is no cultural or archaeological evidence to shed light on the motives behind the trepanation. We believe that the procedure was purely therapeutic, based on the location of the trepanned aperture. Since the majority of trepanations identified in archaeological skeletal remains worldwide have been undertaken on the left side of the cranium (left side of the frontal bone and the left parietal bone), some authors [1,38,39] suggest that this may be due to interpersonal violence. In a scenario where a right-handed adversary faces the victim most injuries caused by the attacker will be located on the left side of the victim's body. The analysed skeleton does not show any signs of antemortem cranial trauma that would require trepanation, but in most of the cases healed lesions do not reveal signs of the original trauma, as the damaged bony units are cut out in the course of trepanation [21].

Among other characteristics, trepanations may vary in terms of the methods used. So far, at least four distinguishable methods have been recorded [1,9,40]: 1) scraping - a sharp-edged tool is repeatedly scraped over a designated portion of the bone until the vault wears away and oval or round-shaped perforation is complete with the edges that have a broad shallow bevel; 2) chiselling - a round/oval groove, usually with serrated, steeply bevelled edges is made with a pointed instrument. Numerous evidence suggests that other devices such as drills or crown saws were also used, especially during the Roman and medieval times [41]; 3) linear grooving - a sharp-edged tool is applied at right angle to the vault surface and moved back and forth until a linear groove penetrates the skull. Three more grooves are necessary to produce a rectangular shape; 4) joining of adjacent burr holes - a circle of small holes are drilled through the skull vault, the bridges broken, and the enclosed bone removed. This technique was mostly limited to Peru [1].

The morphology of the trepanned aperture from Ludbreg strongly indicates that the scraping technique was used in this particular case. Scraping is the oldest trepanning technique [42]; it provides the greatest control over the process and involves the lowest risk of damaging the brain [37]. For this procedure, especially before the widespread use of metals, a sharp-edged oval stone was applied, but more advanced instruments such as metal scrapers

(raspatories) were also used [41]. Considering the archaeological context, it is possible that a raspatory was used for the trepanation of the analysed individual.

Since neither bone nor brain possess pain receptors [43], trepanation should not have been particularly traumatic or painful after the scalp and soft tissue had been pierced [44]. However, it has been suggested that sleep could have been induced in people who were being prepared for trepanation by making them ingest large amounts of alcoholic drinks [45,46]. Besides, extracts from plants could also have been used for anaesthesia; coca was most probably used in South America [46,47], while in Europe, especially during the medieval period, the analgesic properties of poppy and nightshades were known, and may have been used in these procedures [48,49]. In certain cases, an alternative to anaesthesia was to restrain the patient. In the presented case it is not possible to distinguish which type, if any, of anaesthesia was used, but the most logical explanation involves the use of a strong alcoholic drink or plant with analgesic properties.

The fact that the edges of the studied lesion are smooth and exhibit extensive remodelling and that the diploë is not visible is a strong indication that the individual survived the operation. Nerlich et al. [50] conducted a study on dry bone samples obtained from individuals who had suffered intravital trepanation for medical reasons in recent times and survived from a few minutes up to 34 years after the procedure was conducted. The degree of healing of the Ludbreg trepanation closely corresponds to those specimens who lived between four and 34 years after the operation, so it may assumed that the Ludbreg male lived for a long time, at least a couple of years after the operation was performed.

Regarding the probability of survival, one wonders what the survival rates of such complicated neurosurgical interventions were in past populations. It seems that in the Roman and medieval times mortality was very high, probably due to infections [16] caused by the trepans that were made of metal and washed between interventions, turning them into potential carriers of bacteria [44]. In prehistoric periods the survival rates in procedures using stone instead of metal were probably much higher because lesions were smaller [51], procedures shorter [42], and freshly knapped stone tools were as good as sterile [6]. Stewart [52] examined 2000 trepanned skulls; half of them indicated long-term and additional 16% short-term survival - based on complete and partial healing of bone, while Bennike [53] reported an 80%

survival. However, only until recently, cranial surgery, including trepanation, was principally extradural. If the dura mater was penetrated, lethal complications such as meningitis, brain abscess, and critical intracerebral bleeding could develop. Most likely, ancient surgeons were careful to avoid breaching the dura because without respecting these anatomical landmarks survival rates as high would not have been possible [42].

Beside skeletal remains, probably the most comprehensive data on trepanation procedures, especially those conducted in "primitive" cultures, are provided by ethnographic texts. According to the ethnographic sources from the Balkan region [54,55] the tradition of trepanation in Serbia, Albania, and Montenegro continued well into the 20th century; it was performed mostly due to therapeutic reasons, but it was also a form of punishment. During trepanation, cylinder crown saws were used to remove the bone, sometimes without anaesthesia, but otherwise using spirits (*rakija*) as anaesthetic [54]. There are literally hundreds of 20th century accounts of trepanation, particularly in Oceanic and African cultures [56]. Especially detailed and recent ones concern the Kissii tribe in Kenya and include photographs of the surgical instruments, practitioners and patients, X-rays of the skulls of surviving patients, detailed interviews, and even a documentary film [56,57].

Trepanation was clearly a phenomenon of global proportions, practiced by past populations as well as "primitive" cultures of the 20th century. The absence of similar studies in Croatia is surprising, considering a wealth of archaeological and ethnographic sources that testify on the practice of trepanation, particularly those originating from the immediate vicinity of the present-day Croatia. Therefore, we hope that this study will encourage further and multidisciplinary research, not only in Croatia but also in the wider region.

Conclusion

Trepanation presented in this paper seems to be typical of early medieval Central Europe. Our comprehensive anthropological analysis points to a complex neurosurgical procedure on an adult male, most probably for therapeutic reasons, using a scraping technique. The trepanned patient survived the operation and probably lived for a longer period of time, apparently without major complications. At the moment, we cannot establish whether the trepanation was performed in Ludbreg, where the individual was buried, or somewhere else, and whether it was carried out by a trained physician or a

priest or shaman. Hopefully, further multidisciplinary research of this skeleton and its archaeological context that is planned in the near future will provide more definite answers.

References

1. Aufderheide A.C., Rodríguez-Martín C. 1998. The Cambridge Encyclopedia of Human Paleopathology. Cambridge University Press, Cambridge.
2. Alt K.W., Jeunesse C., Buitrago-Téllez C.H., Wächter R., Boës E., Pichler S.L. 1997. Evidence for stone age cranial surgery. Nature 387: 360.
3. Lillie M.C. 1998. Cranial surgery dates back to Mesolithic. Nature 391: 854.
4. Crubézy É., Bruzek J., Guilaine J., Cunha E., Rougé D., Jelinek J. 2001. The antiquity of cranial surgery in Europe and in the Mediterranean basin. C R Acad Sci Ser IIa: Sci Terre Planets 332: 417-423.
5. Capasso L., Michetti E., Pierfelice L., D'Anastasio R. 2002. Neurosurgery 7000 years ago in central Italy. Lancet 359: 2206.
6. Piek J., Lidke G., Terberger T., von Smekal U., Gaab M.R. 1999. Stone age skull surgery in Mecklenburg-Vorpommern: a systematic study. Neurosurgery 45: 147-151.
7. Liu C.Y., Apuzzo M.L.J. 2003. The genesis of neurosurgery and the evolution of the neurosurgical operative environment: Part 1 - Prehistory to 2003. Neurosurgery 52: 3-19.
8. Prioreschi P. 1996. Neolithic skull trephining. In: Prioreschi P. (ed.), A History of Medicine: Primitive and Ancient Medicine. Horatius Press, Omaha, 21-32.
9. Lisowski F.P. 1967. Prehistoric and early historic trepanation. In: Brothwell D.R., Sandison A.T. (eds.), Diseases in Antiquity. Charles C. Thomas, Springfield, 651-672.
10. Nemeskéri J., Kralovánszky A., Harsányi L. 1965. Trephined skulls from the tenth century. Acta Archaeol Hung 17: 343-367.
11. Jordanov J., Dimitrova B., Nikolov S. 1988. Symbolic trepanations of skulls from the Middle Ages (IXth-Xth century) in Bulgaria. Acta Neurochir 92: 15-18.
12. Ferencz M. 1992. A trephined skull from Hévízgyörk. Ann Hist-Nat Mus Nat Hung 84: 185-188.
13. Grynaeus T. 1999. Skull trephination in the Carpathian Basin (8th-13th century A.D.) Mankind Q 40: 131-142.
14. Lunardini A., Caramella D., Mallegni F., Fornaciari G. 2000. Frontal fracture with therapeutic trepanation in an early medieval skull from Northern Italy. J Paleopathol 12: 21-25.

15. Jančová M., Rühli F. 2001. Frühmittelalterliche tschechische Trepanationen evaluiert mittels Makroskopie, konventionellem Röntgen und hochauflösender Computertomographie - erste Resultate. Bull Schweizer Gesell Anthropol 7: 43-49.

16. Weber J., Czarnetzki A. 2001. Trepanations from the early medieval period of southwestern Germany - indications, complications and outcome. Zentralbl Neurochir 62: 10-14.

17. Facchini F., Rastelli E., Ferrero L., Fulcheri E. 2003. Cranial trepanation in two skulls of early medieval Italy. HOMO 53: 247-254.

18. Bereczki Z., Marcsik A. 2005. Trephined skulls from ancient populations in Hungary. Acta Med Lit 12: 65-69.

19. Mikić Ž. 2006. Trepanacija lobanja na antičkom Viminacijumu - antropološke informacije. Arh Prir Nauk 1: 9-20.

20. Szathmáry L., Marcsik A. 2006. Symbolic trephinations and population structure. Mem Inst Oswaldo Cruz 101 (Supp 2): 129-132.

21. Bereczki Z., Molnár E., Marcsik A., Pálfi G. 2010. Evidence of surgical trephinations in infants from the 7th-9th centuries AD burial site of Kiskundorozsma-Kettőshatár. Acta Biol Szeged 54: 93-98.

22. Bereczki Z., Molnár E., Marcsik A., Pálfi G. 2013. Rare Types of Trephination from Hungary Shed New Light on Possible Cross-cultural Connections in the Carpathian Basin. Int J Osteoarchaeol. doi: 10.1002/oa.2304.

23. Germanà F., Fornaciari G. 1992. Trapanazioni, craniotomie e traumi cranici nell'Italia antica. Giardini Editori, Pisa.

24. Arnott R., Finger S., Smith C.U.M. (eds.). 2003. Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse.

25. Gross C.G. 2003. Trepanation from the paleolithic to the internet. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 307-322.

26. Tullo E. 2010. Trepanation and Roman medicine: a comparison of osteoarchaeological remains, material culture and written texts. J R Coll Physicians Edinb 40: 165-171.

27. Rocca J. 2003. Galen and the uses of trepanation. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 253-271.

28. Graham M. 2003. Why Trepan? Contributions from Medical History and the South Pacific. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 323-345.

29. Como J. 1925. Das Grab eines römischen Arztes in Bingen. Germania 9: 152-162.

30. Künzel E. 1983. Medizinische Instrumente aus Sepulkralfunden der römischen Kaiserzeit. Rheinland Verlag, Bonn.

31. Jackson R. 2003. The Domus 'del chirurgo' at Rimini: an interim account of the medical assemblage. J Rom Arch 16: 312-321.

32. Anda T. 1951. Recherches archéologioques sur la pratique médicale des Hongrois a l'epoque de la conquete du pays. Acta Archaeol Hung 1: 251-316.

33. Malez M., Nikolić V. 1975. Patološka pojava na čovječjoj prethistorijskoj lubanji iz pećine Bezdanjače u Lici. Rad Jugosl Akad Znan Umjet 17: 171-179.

34. Pleše T. 2011. The Results of Cultural Management of the Croatian Archaeological Heritage with Special Consideration for Cost Effectiveness: The Case of Roman Iovia (Ludbreg). Preserving Archaeological Remains in Situ: Proceedings of the 4th International Conference, 23-26 May 2011, Copenhagen, Denmark. Conserv Manage Archaeol Site 14: 310-321.

35. Vikić Belančić B. 1984. Sustavna istraživanja u Ludbregu od 1968. - 1979. godine. Vjesn Arheol Muz Zagreb 16-17: 119-166.

36. Buikstra J.E., Ubelaker D.H. 1994. Standards for data collection from human skeletal remains. Arkansas Archaeological Survey, Fayetteville.

37. Ortner D.J. 2003. Identification of Pathological Conditions in Human Skeletal Remains. Academic Press, San Diego.

38. Russu I.G., Bologa V. 1961. Trepanationen im Gebiet des Heutigen Rumänien. Sud Arc Gesch Med Natur 45: 34-66.

39. Murphy E.M. 2003. Trepanations and Perforated Crania from Iron Age South Siberia: An Exercise in Differential Diagnosis. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 209-221.

40. Brothwell D.R. 1994. Ancient trephining: Multi-focal evolution or trans-world diffusion? J Paleopathol 6: 129-138.

41. Kirkup J. 2006. The Evolution of Surgical Instruments: An Illustrated History from Ancient Times to the Twentieth century. Norman Publishing, Novato.

42. Weber J., Wahl J. 2006. Neurosurgical aspects of trepanations from Neolithic times. Int J Osteoarchaeol 16: 536-545.

43. Hong B., Hermann E.J., Klein R., Krauss J.K., Nakamura M. 2010. Surgical resection of osteolytic calvarial lesions: clinicopathological features. Clin Neurol Neurosurg 112: 865-869.

44. López B., Caro L., Pardiñas A.F. 2011. Evidence of trepanations in a medieval population (13th–14th century) of northern Spain (Gormaz, Soria). Anthropol Sci 119: 247-257.

45. Keller M. 1966. Alcohol in health and disease: some historical perspectives. Ann N Y Acad Sci 133: 820-827.

46. Rose F.C. 2003. An Overview from Neolithic Times to Broca. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 347-363.

47. Vogel V.J. 1970. American Indian Medicine. University of Oklahoma Press, Norman.

48. Prioreschi P. 2003. Medieval anesthesia - the spongia somnifera. Med Hypotheses 61: 213-219.

49. Sabatowski R., Schafer D., Kasper S.M., Brunsch H., Radbruch L. 2004. Pain treatment: a historical overview. Curr Pharm Des 10: 701-716.

50. Nerlich A., Peschel O., Zink A., Rösing W. 2003. The Pathology of Trepanation: Differential Diagnosis, Healing and Dry Bone Appearance in Modern Cases. In: Arnott R., Finger S., Smith C.U.M. (eds.), Trepanation: History, Discovery, Theory. Swets & Zeitlinger, Lisse, 43-51.

51. Campillo D. 1984. Neurosurgical pathology in prehistory. Acta Neurochir 70: 275-290.

52. Stewart T.D. 1958. Stone Age Skull Surgery: A General Review, with Emphasis on the New World. Ann Rep Smithsonian Inst 1957: 469-491.

53. Bennike P. 1985. Paleopathology of Danish skeletons. Akademisk Forlag, Copenhagen.

54. Trojanović S. 1900. Trepanationen bei den Serben - Ein anthropologischer Beitrag. Korresp Dtsch Ges Anthropol Ethnol Urgesch 31: 18-23.

55. Barjaktarović M. 1948. O šaronjanju (trepanaciji) u Crnoj Gori. Stvaranje 11/12: 553-557.

56. Margetts E.L. 1967. Trepanation of the skull by the medicine-men of primitive cultures, with particular reference to present day native east African practice. In: Brothwell D.R., Sandison A.T. (eds.), Diseases in Antiquity. Charles C. Thomas, Springfield, 673-701.

57. Grounds J.G. 1958. Trephining of the skull amongst the Kissii. E Afr Med J 35: 369-373.

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Sažetak

U radu je predstavljen slučaj trepanacije lubanje koja potječe iz Ludbrega, grada na sjeverozapadu Hrvatske. To je tek drugi slučaj trepanacije zabilježen na ljudskim koštanim ostacima iz arheološkog konteksta s područja Hrvatske. Trepanacija je bila obavljena na odraslom muškarcu koji je bio pokopan u grobu pod tegulama na nalazištu Vrt Somođi. Arheološki kontekst i radiokarbonska analiza uzorka ljudske kosti datiraju ukop u V. stoljeće, tj. u razdoblje seobe naroda. Trepanacijski otvor nalazi se na lijevoj strani lubanje, tj. na lijevoj strani čeone kosti i lijevoj tjemenoj kosti. Otvor je ovalna oblika i probio je sva tri sloja kosti, dok je tvrda moždana ovojnica bila potpuno izložena. Neurokirurški zahvat najvjerojatnije je bio izveden zbog terapeutskih razloga (ozljeda glave) uz upotrebu tehnike struganja. Morfologija trepanacijskog otvora snažno sugerira da je osoba preživjela operaciju i nakon nje poživjela duže vrijeme, najmanje nekoliko godina.

Ključne riječi: *trepanacija lubanje, antropološka analiza, tehnika struganja, V. stoljeće, Ludbreg, Hrvatska*