

Mastoid Trepanation in a Deceased from Medieval Croatia: A Case Report

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ABSTRACT

We present a rare case of infratentorial mastoid trepanation, by drilling, from medieval Croatia. An artificial antemortem opening was found in a male skeleton from the 11th century cemetery Zvonimirovo. It was placed roughly at the intersection of the Frankfurt's plane and the midline of the right mastoid. The right posterior parietal of the deceased also exhibited a callus-like formation consistent with the linear cranial fracture. Our aim was to investigate by computed tomography (CT) a possible presence of otopathology – a chronic middle ear infection – MEI/mastoiditis or cholesteatoma. On the other hand, both standard radiography and CT were employed in a cranial fracture diagnostic agreement. The generated CT scans confirmed the presence of an artificial hole running into a well defined trepanne canal connected with the antrum. The presence of otopathology was not established. The radiography and CT substantiated the presence of a linear posterior parietal discontinuity – without displacement, in front of the right lambdoid suture. From the medical point of view, it would be unusual to perform infratentorial – mastoid trepanation for reasons of treating supratentorial trauma, i.e. possible posttraumatic acute subdural hematoma (PTASDH). However, since there was a lack of CT evidence of osteolysis in ME, there is a possibility of medieval trepanation procedure performed for reasons of posttraumatic treatment. To our best knowledge, usually, ancient trepanations described in Croatian bioarchaeology and all over the world are supratentorial and do not always reveal such sophisticated surgical techniques.

Key words: medieval surgery, mastoid drilling, otopathology, supratentorial trauma, computed tomography, Croatia

Introduction

The trepanation – artificial removal of the bone from the cranial vault, has been practiced since ancient times^{1,2} and probably traces back to Mesolithic Age³. There is a substantial number of various examples of trepanation reported from all over the world: Europe, Near East, Africa, Melanesia^{2–9}, Asia¹⁰, the Americas^{4,11,12}. An ancient trepanation was usually performed for three different purposes: medicine-related (surgical), the so-called cultic or magic-related and symbolic purposes^{1,2}. In terms of medicine-related purposes, the ancient trepanation was generally practiced for relief of cranial fractures/wounds effects, such as an increased intracranial pressure, headaches, or other conditions^{1,2}. However, there are also a few examples of medicine-related trepanation associated with possible ear pathologies. So far, such trepanations were described by Brothwell¹³, Mann¹⁴, Kato et al.¹².

With regard to the types of trepanation, it could be performed by scraping through the bone with a sharp implement or drilling a circle of small holes and breaking

or cutting the intervening bone¹. In terms of small cranial trepanne and/or »drill« holes, they are rarely reported in bioarchaeological studies and it is usually the question either of multiple cranial openings^{1,14} or openings accompanying various types of primary trepanations^{7,12}. There are also a few examples of the so-called »double-« or »triple-like«, i.e. 2–3 connected and relatively small cranial »drill« holes, like those identified in Celtic crania, reported from Austria¹⁵. However, one has to point out that usually ancient trepanations described all over the world are supratentorial, i.e. occurring above the tentorium. The tentorium cerebelli is an expansion of the dura matter separating the cerebellum from the inferior portion of the occipital lobe¹⁶. Aufderheide and Rodríguez-Martín¹⁷ define the (supratentorial) trepanation technique as a procedure which 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. On the

other hand, an infratentorial trepanation technique, such as a mastoid trepanation, by drilling, in the present case (so far not described for ancient crania), occurs below the tentorium cerebelli.

There are some important criteria for identifying if a cranial opening has been made intentionally (by mechanical intervention)¹, i.e. to determine whether a hole stems from possible accidental causes, such as excavation or whether it was the action of animals or plant roots. The same is the case with a possible presence of congenital alterations and/or anomalies which could cause some perforations as well as infectious processes and ectocranial neoplasias⁸. The next step is to clarify antemortal/post-mortal status of the opening and the presence of accompanying fracture¹.

As for the ancient/historical practice of trepanation from the Croatian territory, there is a general lack of scientific articles referring to such topic. So far, there were only two trepanation-related cases reported – one prehistoric¹⁸, the other from a 5th century AD¹⁹. However, they are both supratentorial. This paper presents a rare case of unusual infratentorial mastoid trepanation, by drilling, in an individual from the 11th century Croatian burial complex Zvonimirovo. Given the anatomic position of an artificial mastoid »defect«, made for reasons of possible otopathology, we aimed to establish by computed tomography (CT) whether the surgery was performed due to possible chronic middle ear infection (MEI)/mastoiditis, or cholesteatoma. To the best of our knowledge, this is a unique case of an ancient infratentorial mastoid trepanation described so far.

Case Report

The skeleton of an individual studied for a possible medicine-related therapeutic mastoid trepanation was



Fig. 1. Map of Croatia (Europe) with an enlarged detail – the map of Zvonimirovo-Veliko Polje near Virovitica. The Zvonimirovo-Veliko Polje map was provided by courtesy of Tomičić²⁰.

excavated in 1995 from a primary single inhumation No. 3¹, at the burial complex Zvonimirovo, near Virovitica (Virovitica-Podravina County, Croatia) (Figure 1). Zvonimirovo is an early medieval cemetery where the Institute of Archaeology (Zagreb) and the Museum of Virovitica started systematic excavation in 1993. According to grave enclosures uncovered at the site, the cemetery was related to the Bijelo Brdo culture of the 11th century²⁰. A demographic and pathological study of the early Zvonimirovo series was presented in an earlier report by Boljunčić²¹. Apart from the established kinship relationship among several of the Zvonimirovo deceased, a recent molecular study also generated an affiliation of Zvonimirovo with the general Croatian population²².

Skeletal remains of the individual from Zvonimirovo burial No. 3 belonged to the initial collection of around ten skeletons unearthed in 1995 and housed at the Institute of Archaeology in Zagreb. There was no evidence of any other cases of trepanation in the mentioned series. The same was true for the Zvonimirovo series reported in an earlier study. Likewise, there were no cranial fractures, neither in the aforementioned series, nor in an earlier study²¹.

The neurocranium was very well preserved, the viscerocranium moderately damaged, also with the established lack of the mandible. The rest of the skeleton was in a moderately preserved state, including the established lack of the following bone elements: the hyoid, sternum, all vertebrae (except for the damaged atlas), the entire rib cage, the sacrum, the pubic bones. Sets of hand and foot bones were also incomplete.

Sex-determination was based on the cranial and pelvic dimorphism among male and female skeleton^{23,24}. Aging techniques followed the standards for ectocranial suture closure²⁵ supplemented by criteria for the maxillary suture closure²⁶, and (maxillary) dental attrition²⁷. The two indices¹¹, were calculated after Martin and Saller²⁸.

Pathologies were scored after visual cranial inspection. Computed tomography was employed in the investigation of the mastoid »defect«, i.e. supposed otopathology. It was performed by a Siemens Sensation 16 AG multi detector CT scanner (slice thickness 1mm). Both conventional radiography and multisliced CT (multiplanar reformatting techniques^{III}) were employed in a cranial fracture diagnostic agreement. The pathology was defined after Ortner¹, Facchini et al.⁸, Gray¹⁶, Aufderheide and Rodriguez-Martin¹⁷, as well as Qureshy³⁰.

Based on sex and age criteria, a medieval individual from Zvonimirovo burial No. 3 was identified as a younger adult male apparently in his earlier thirties (30–34). The cranium [long – dolichocranic (I1:73.2), with very

¹ Burial designation followed the original burial No. assigned during the initial excavation.

¹¹ Cranial Index (I1) and Upper Facial Index (I39)²⁸.

^{III} Multiplanar reformatting technique is an extraction of images in planes other than the original stack²⁹.

slender – hyperlepten upper face [I39:60] exhibited the presence of a small artificial circular bone defect to the right mastoid with additional trauma to the right posterior parietal (Figure 2–3). The defect was located roughly at the intersection of the Frankfurt’s plane and the mid-line of the right mastoid process. Gross morphology of »perforated« mastoid was consistent with an antemortal trepanne hole made by drilling. Bone structure around the hole was compact, bone margins smooth with a delicate marginal osteosclerosis. There were no outer signs of bone infection (Figure 3). The external maximum horizontal diameter of the opening measured with the caliper was 6.6mm. The axial CT scans at the level of both ME (tympanic cavities) and antra showed the presence of an artificial hole running into the trepanne canal connected with the posterior inferior antrum (Figure 4). The margins of the canal were regular and clearly osteosclerotic (Figures 4 and 5). The maximum transversal diameter of the opening obtained from CT was 7.6mm. The maximum transversal diameter of the canal at the turn of its mid-section into the medial third was 9.4mm. The maximum transversal diameter of the canal beside the



Fig. 2. Right lateral aspect of the male cranium from the Zvonimirovo burial No. 3 with an antemortal infratentorial mastoid trepanne hole. Additional callus-like formation is placed in the right posterior parietal (marked with white arrows).

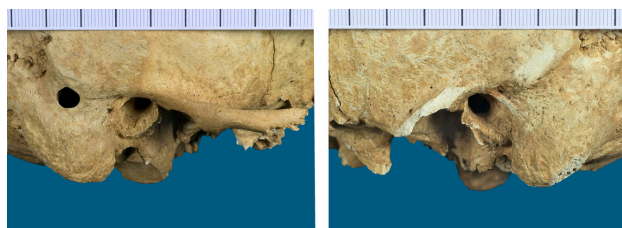


Fig. 3. Enlarged comparative lateral gross aspect of the right (trepanned) mastoid (on the left) and the left normal mastoid (on the right). Mild exostosis is present at the lower margin of the right acoustic porus.

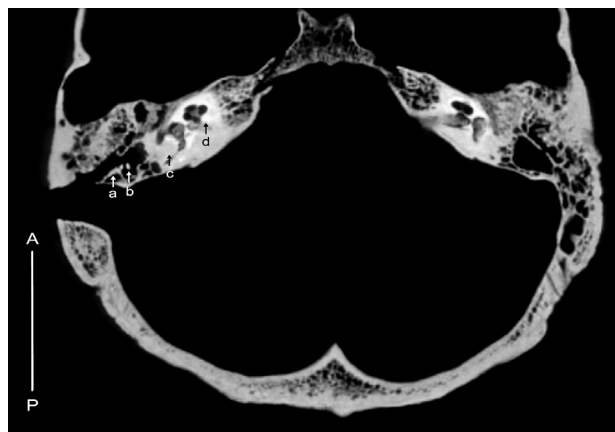


Fig. 4. Axial CT scan of both tympanic – middle ear (ME) cavities and antra at the level of connection of the right mastoid trepanne canal with the posterior inferior antrum. Displaced antral position of incus (a) and malleus (b), posterior semicircular canal (c), otic capsule (d).

sigmoid sinus was 12mm. The maximum length of the trepanne canal was 18.8 mm at the anterior margin and 16mm at the posterior margin. The status of the right tympanic cavity (tympanum), epitympanum, horizontal semicircular canal and inner auditory meatus was normal although with the presence of the sediment matrix. The facial nerve canal and right otic capsule – bone around the labyrinth were intact. The same applies to the left-hand side (Figure 5). The presence of two intact (dislocated) auditory ossicles – the malleus and incus (the stapes could not have been identified) was established in the right posterior antrum (Figures 4 and 5). The same was true for the left posterior antrum. The axial CT scan of the right mastoid exhibited completely preserved periantral cellules and intercellular septa of the mastoid apex. The same was

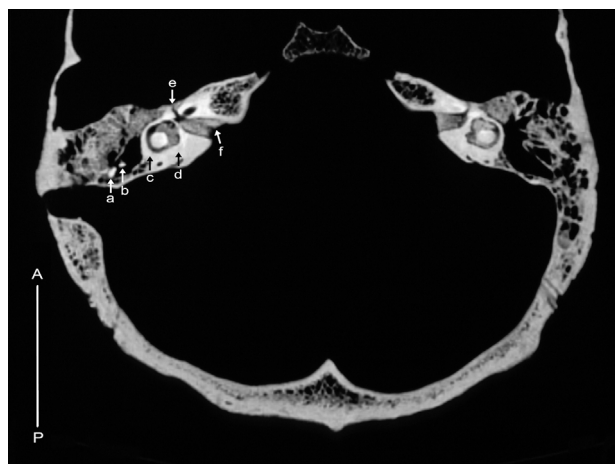


Fig. 5. Axial CT scan of both ME cavities and antra at the level of visible inner auditory meatus and facial nerve canal. Incus (a) and caput mallei (b) in the right antrum, horizontal semicircular canal (c), otic capsule (d) labyrinthal part of the facial nerve canal (e), inner auditory meatus filled with the sediment matrix (f).

the case with the left mastoid (Figure 6). A fairly widened right sigmoid sinus groove was completely filled with the sediment matrix. The right jugular foramen was only slightly enlarged. Both external auditory meati were normal without stenosis, just showing mild exostosis (Figure 6). Neither discrete traits (in the form of enlarged sutural/exsutural mastoid foramina), nor congenital anomalies were present. The same was the case with infectious processes and ectocranial neoplasias.

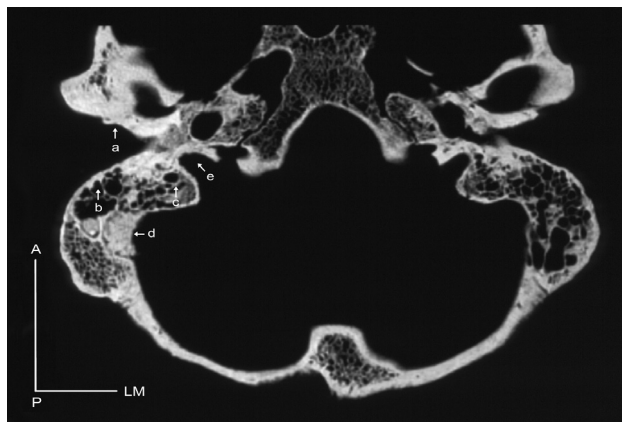


Fig. 6. Axial CT scan at the level of both mastoid regions. Outer meatal exostosis (a), periapical mastoid cellules (b) intercellular mastoid septa (c), right sigmoid sinus groove fairly enlarged and filled with the sediment matrix (d), jugular foramen slightly enlarged (e).

The presence of an irregular semicircular callus-like formation in the right posterior parietal, running delicately towards the right mid-parietal, was associated with bone discoloration mostly in the right posterior parietal (Figure 2). Standard radiograph exhibited a delicate semicircular linear transparency in the right posterior parietal, in front of the lambdoid suture (Figure 7). Generated

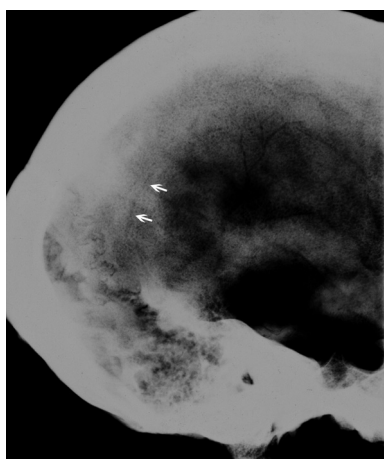


Fig. 7. X-ray of the right posterior parietal with a delicate semicircular linear transparency (marked with white arrows) in front of the lambdoid suture.

CT scans (combined) showed the presence of a submillimetre non-displaced right parietal discontinuity localized at the turn of its posterior lower third to the middle third. The bone fracture was extended from the outer plate over the diploë, ending up in the inner plate (Figure not shown).

Discussion

The generated CT data of the cranium from Zvonimirovo burial No. 3 confirmed the presence of an antemortal artificial trepanne hole in the right mastoid (made by drilling), running into a well-defined canal connected with the antrum. However, the supposed presence of the chronic MEI and/or cholesteatoma could not be established. Namely, such pathologies would destroy osteological structures around the right middle ear (ME). The same was true for mastoiditis, i.e. the preserved intact intercellular septa of the right mastoid apex and periantral cellules excluded the presence of a possible otitic process secondary to MEI. Additionally, the preserved dislocated, although intact auditory ossicles^{IV} – the malleus and incus (the stapes was probably lost during/after the excavation) also substantiated the lack of the chronic MEI.

On the other hand, standard radiography confirmed the presence of a simple linear semicircular parietal fracture in front of the right lambdoid suture – apparently due to higher spatial resolution than that obtainable by CT²⁹. In addition, multiplanar reformatting of a 3D data set allowed assessing the status of the fracture (the width, absence of the displacement and precise localization), which could not be scored by plain radiography. An adequate fracture healing status^V was difficult to establish by radiography, because fractures of the skull (also of the phalanges, scaphoid, calcaneus, and those of intra articular surfaces) develop minimal to no callus visible by radiography^{33,34}. Linear skull fractures – low-energy blunt traumas over a wide cranial area³⁰, which are most common fractures of the cranium, if non-displaced heal spontaneously without treatment. Adults typically heal in 2–3 years^{35,36}. However, from the present time clinical practice it is also true that some skull fractures never heal completely and patients could live long without a complete fracture sanation. There is a variety of complications resulting from such skull fractures, among other, a post-traumatic acute subdural hematoma (PTASDH) – a collection of blood outside the brain (between the layers of tissue that surround the brain – the dura and the arachnoid), usually caused by severe head injuries/cranial fractures³⁷. Matsuyama et al.³⁸ point out to a high mortality of PTASDH in modern ages (60–80%). Such outcomes must have been particularly high in the pre-antibiotic medieval period. However, osteological and CT evidence, i.e.

^{IV} Auditory ossicles are rarely discovered in archaeological excavations and osteological collections³¹, although they can be useful in paleopathological evaluation of the chronic otitis media/otosclerosis and beyond³².

^V Due to mere submillimetre width of the bone discontinuity, it was difficult to obtain the quality CT cross-sectional images.

bone reparation of both the trepanne hole and canal strongly substantiate surviving of the individual (quite) some time after the performed procedure.

There is a spectrum of instruments (drill trepanons?) with which mastoid trepanation by drilling could be performed. The anatomical position of the trepanne canal – connected with the posterior inferior antrum, points out to a rather sophisticated technique performed by a skilled medieval surgeon. This is substantiated by the lack of bone damage around the facial nerve canal. Generally, fair knowledge about the internal bone structures in the human body and bone regeneration has been known ever since the early prehistory⁷. Apparently the same is the case with a medieval period from the territory of Croatia. The presence of a fairly widened right sigmoid sinus groove in the Zvonimirovo medieval individual is just a result of an anatomical variation. The terminal part of the sigmoid groove is usually larger on the right with no significant sex-related difference. The same is true with jugular fossa and venous portion of jugular foramen³⁹.

Described mastoid trepanation, by drilling, is an infratentorial trepanation technique, i.e. occurs below the tentorium cerebelli. From the medical point of view, it would be unusual to perform an infratentorial trepana-

tion, i.e. by intervening into the posterior cranial fossa for reasons of treating supratentorial trauma, e. g. possible posttraumatic acute subdural haematoma (PTASDH). However, since there was a lack of CT evidence of osteolysis in ME, there is a possibility of medieval trepanation procedure performed for reasons of posttraumatic treatment.

In conclusion, the present paper reports an unusual antemortem infratentorial mastoid trepanation, by drilling, revealing a sophisticated operating procedure. Two ancient cases of trepanations reported from the Croatian territory and numerous from places all over the world are supratentorial and mostly do not reveal such sophisticated surgical techniques.

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TREPANACIJA MASTOIDA U POKOJNIKA IZ SREDNJOVJEKOVNE HRVATSKE

SAŽETAK

Predstavili smo rijedak slučaj infratentorijalne trepanacije mastoida, bušenjem kosti, iz srednjovjekovne Hrvatske. Umjetni zaživotno načinjen otvor pronađen je na kosturu iz groblja Zvonimirovo koje potječe iz 11. stoljeća. Otvor je smješten približno na sjecištu frankfurtske ravnine i središnje linije desnog mastoida. Desni stražnji dio tjemene kosti pokojnika također prikazuje tvorbu nalik ožiljnoj koja odgovara linearnom prijelomu lubanje. Cilj je bio ispitati moguću nazočnost patologije uha – kronične upale srednjeg uha/mastoiditisa ili holesteatoma pomoću računalne tomografije (CT). S druge strane, rabili smo standardnu radiografiju i CT kako bismo uskladili tumačenje prijeloma lubanje. Dobiveni CT presjeci potvrdili su nazočnost umjetnog mastoidnog otvora koji se nastavlja u dobro definirani trepanacijski kanal povezan s antrumom. Međutim, nismo utvrdili nazočnost patologije uha. Pomoću radiografije i CT-a potvrdili smo nazočnost linearnog diskontinuiteta tjemene kosti – bez pomaka, ispred desnog lambdoidnog šava. S medicinskog gledišta bilo bi neobično izvoditi infratentorijalnu trepanaciju mastoida u cilju tretiranja supratentorijalne traume, tj. mogućeg posttraumatskog akutnog subduralnog hematoma (PTASDH). Međutim, budući da nema CT dokaza osteolize u srednjem uhu, moglo bi biti riječi o srednjovjekovnom trepanacijskom postupku u cilju posttraumatskog liječenja. Prema našim najboljim saznanjima trepanacije iz starijih razdoblja opisane u hrvatskoj bioarheologiji i diljem svijeta obično su supratentorijalne i ne podastiru uvijek tako sofisticirane kirurške tehnike.