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# Craniotomy as a Prehistoric Medical Practice: A Case of Antemortem Cranial Trepanation in Southern Siberia in the Late Bronze Age

*Complete trepanation with the removal of the inner bone plate was studied on a cranium of a male aged ca 35, from a Late Bronze Age burial at Anzhevka, in the Krasnoyarsk-Kansk forest-steppe, dating to 1000–700 BC. Certain burials, including that with a trephined cranium, reveal traces of post-funerary rituals. The individual displays the Paleosiberian (Baikal) combination of craniometric and dental characteristics. The results of the macro- and microscopic analysis of the affected area, along with multislice computed tomography (MSCT), suggest that the trepanation was performed to treat osteomyelitis of the parietal bone with an epidural abscess (empyema), caused by an open depressed fracture of the left parietal bone, inflicted by a tool with a small contact area. In modern forensic practice, such perforations are attributed to hammer blows. This would explain the absence of linear fractures of the parietal bone around the zone of trepanation. Craniotomy with the removal of the osteomyelitic focus and the emptying of the epidural abscess led to a prolonged preservation of the patient's life. The results of a traceological analysis suggest that the aperture was made by scraping, and a thin tetrahedral tool was used to remove the bone fragment. Possibly the use of bronze instruments, known to have antiseptic properties, helped the ancient healer to cope with an advanced infectious process.*

Keywords: *Late Bronze Age, trepanation, multislice computed tomography, epidural abscess.*

## Introduction

Some manifestations of the antemortem manipulations found in archaeological skulls can be attributed to craniotomies with positive results. Such phenomenon has been known for at least 10–12 millennia, beginning in Mesolithic times (Goykhman, 1966; Crubezy et al., 2001; Lillie, 2003). According to Prioreschi (1996: 22), more than 15 thousands of trepanned skulls were excavated at archaeological sites in Eurasia, North Africa, and America. The shapes of the edges of the trepanation wounds unequivocally suggest that many of them were performed antemortem. The mortality rate for the Mesolithic and Neolithic individuals who underwent such a surgery was about 10 %, while in the Bronze Age it increased to 30 % (Mednikova, 2004: 53). It can be thus hypothesized not only that the ancient healers were skilled in the trepanation surgery, but that they also knew anesthesia techniques, were able to stop bleeding from the abundantly supplied soft and bone tissues of the skull, and, finally, were aware of how to prevent infection of the wound.

The first important question to be solved when studying a case of ancient antemortem craniotomy is: why was it performed? Such surgical intervention is not completely safe and harmless even with the use of modern neurosurgical methods (Krivoshapkin et al., 2014). Three kinds of reason are usually considered: therapeutic, magic or ritual, or a combination thereof (Lisowski, 1967; Prioreschi, 1991). The first kind includes cases of healing of traumas (fractures or wounds), neurological symptoms of increased intracranial pressure, tumors or infections. All these pathologies leave easily recognizable signs on the cranial bones. But even the most detailed consideration of such pathological manifestations can lead to reversal of causes and effects, as was done by Slepchenko et al. (2017). The present study is partially dedicated to a revision of the results of the work of Slepchenko and his colleagues.

Magical or ritual trepanations, both ante- and postmortem, were performed for several purposes. First, they could have opened an entrance/exit for some substances of the unmanifested world or spirits. The piece of bone cut from the skull could be later used as an amulet or talisman. The trepanation apertures made antemortem might have provided access to the parts of the brain that could be manipulated by ancient magicians in order to alter the behavior or consciousness of an individual. Trepanations of this type are difficult to recognize. If there are no pathological manifestations or bone-remodeling around the aperture, it cannot be firmly interpreted as ante- vs. perimortem, because the patient might have died during the operation. Moreover, a craniotomy performed in order to heal a disease not related to changes in bone tissue (e.g. extraction of a helminth) can be erroneously interpreted as magical or ritual. Symbolic trepanations associated with initiation rituals (i.e. transition of an individual to the next social level) display a wide range of modifications. They are usually performed without perforating a bone (Mednikova, 2001: 125–131; 2003).

But medical and ritual (magical) aspects of ancient cranial surgery can be tightly intertwined. Actually, the only unambiguous evidence for the magical or ritual motivation for a craniotomy is the archaeological context of the burial, i.e. some features of the burial customs that distinguish it from other burials.

In Eurasia, skulls with manifestations of antemortem craniotomy were found in burials dated to the period from the Mesolithic to medieval times (see, e.g., (Goykhman, 1966; Mednikova, 2001; Chikisheva, Zubova, Krivoshapkin et al., 2014; Chikisheva, Krivoshapkin, 2017; Crubezy et al., 2001; Lillie, 2003; Lorkiewicz et al., 2005; Weber, Wahl, 2006; Erdal Y.S., Erdal Ö.D., 2011; Kangxin, Xingcan, 2007; Papagrigorakis et al., 2014; Gresky et al., 2016; Slepchenko et al., 2017)). In most cases, when studying complete antemortem trepanations not related to trauma healing, the authors of the cited studies (mostly physical anthropologists) could not come to definite conclusions regarding the reasons for carrying out those operations. These were usually interpreted as magical or ritual manipulations (Gresky et al., 2016). It seems that the role of ritual behavior in the motivation for antemortem craniotomies is to some extent exaggerated. The cases of trepanation from the Bronze and Early Iron Age burials from southern Siberia previously published by the authors of the present study (notably, these are almost all such cases known in the region) did not give any grounds to question their medical purpose (Chikisheva, Zubova, Krivoshapkin et al., 2014; Chikisheva, Krivoshapkin, 2017).

One of the latest such finds, dated to the Bronze Age, was studied by S.M. Slepchenko et al. (2017). We have obtained permission to re-survey this specimen and found it necessary to publish the results of our differential diagnosis and a use-wear analysis, and provide a more detailed description of the archaeological and anthropological context of the specimen.

## Archaeological context of the burial*

A skull with signs of trepanation was found during a rescue excavation near Kansk city, Krasnoyarsk Territory, in 2015. Official name of the site is "Anzhevka. Camp site Nefteprovod-2 (Novosmolenka-2)", while its short name used in publications is "Nefteprovod-2". It is located in the Ilansky District of the Krasnoyarsk Territory, 1.8 km south of the abandoned village of Anzhevka, 4.3 km southwest of the Karapsel settlement, on the right bank of the Kan River, 3 km upstream from the present-day border of Kansk city. The heads of the excavation tend to consider this site as

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a part of the Anzhevka archaeological complex, which includes sites with dates ranging from the Paleolithic to ethnographic modernity.

During the rescue excavations, several burials were detected. Some of the burials were situated separately, while others formed groups at two levels: lower (above-flood) and upper altiplanation terraces. At Nefteprovod-2, fourteen flat-grave burials were identified, the main part of which was concentrated in a small area in the center of the lower altiplanation terrace. Most of the burials contained complete human skeletons. The deceased were buried in an extended supine position; their heads were predominantly oriented to the south-east, upstream of the Kan River. In several cases, the outlines of the graves could be traced in the plan view. The tops of some burials were marked by masonry. Grave goods included bronze knifes, bone daggers, bone tools, and bronze adornments. Some burials contained only fragmented bones, compactly folded in small pits, sometimes covered with masonry. Some bones and stones displayed traces of high-temperature burning. Judging by the grave goods and the artifacts found in the layer where the stone roofs of the burials were found, the main part of the burials was preliminarily dated to the Late Bronze Age (the first third of the 1st millennium BC).

Burial 14, in which the trepanned skull was found, belongs to horizon 4. The grave can be described as an irregularly-shaped pit with unclear boundaries, 1.5× 2.0 meters in size, and 0.4 m in depth. The pit is filled with gray (or black) and brown sandy loam. Inside the pit, lithic artifacts, animal bones, and bone and bronze tools were found. Among these, scattered human skeletal remains were found as well, including a skull and a mandible. The mandible exhibits a green spot due to contact with a bronze object near the chin. The skull was oriented vertically, with the face directed towards the south-east. Under the skull, an assemblage of artifacts was found, including a bone dagger of the Karasuk type, a composite elbow knife, and two arrowheads. The dagger lay horizontally, with the tip oriented towards the south-east; the knife lay parallel to the dagger, with the blade oriented towards the north-east; the arrowheads were stacked on the dagger.

## Anthropological description of the skull

The skull belonged to a male, who died at about 35 years of age (Fig. 1). The age determination was based on the incomplete obliteration of the sutures of the endocranial surface, and the moderate dental wear (point 3 at the incisors, canines, and premolars, and point 4 at the molars). The facial skeleton was fragmentary. The cranial base had been broken down by several blows from a heavy object to the occipital bone (Fig. 2), so the cranial base is absent. But there were no direct traces detected of the contact between the object and the skull. This led us to the assumption that the blows occurred at some distance from the fracture's edge, which is uneven and ragged. The mandible was probably destroyed by those blows as well: its condyles and the lateral parts of the corpus (to the level of molars, for about a half of its height) were split off (Figs. 3, 4). The nature of the fractures on both sides might suggest that the mandible had been separated from the skull's base by breaking out. The damage is more pronounced in the left side.

All manipulations with the remains listed below were carried out after they were partially skeletonized: the skeleton was incomplete—the remaining bones were commingled; the skull was destroyed and placed in a vertical position on the postcranial remains, above the assemblage of grave goods. But the pattern of fractures shows that these were not caused to dry bone, but to bone retaining some of its elastic properties. This is probably a case of a ritual post-inhumation penetration of the grave, which was widespread among various peoples and tribes in the past, and also in ethnographic modernity. In southern Siberia, this tradition was comprehensively studied using the data from the Bronze Age burial assemblages of the Ob-Irtysh interfluve, including the sites belonging to the Irmen culture in its entire area, including the Tomsk region of the Ob (Elovka II cemetery) (Bondarenko, 2016: 14–30), where the Irmen people were contacting the Karasuk population (Matyushchenko, 1974: 158). There has been no such systematic research on disturbed burials in the eastern regions of southern Siberia (Yenisei steppes, Minusinsk Basin, Tuvinian uplands)—which does not actually mean the absence of that phenomenon there.

The set of craniometric traits it was possible to measure was limited:

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|---|---|
| 1. Cranial length | 188 |
| 8. Maximum cranial breadth | 140 |
| 9. Minimal frontal breadth | 89.1 |
| Forehead transverse curvature height | 11.2 |
| Forehead transverse curvature angle | 151.8 |
| 10. Maximal frontal breadth | 115 |


*Fig. 1*. Skull from burial 14 at Anzhevka (*a*) and its internal surface (*b*).


*Fig. 2*. Traces of destruction of the cranial base: directions of the destructive blows (*a*) and the pattern of bone crushing (*b*).

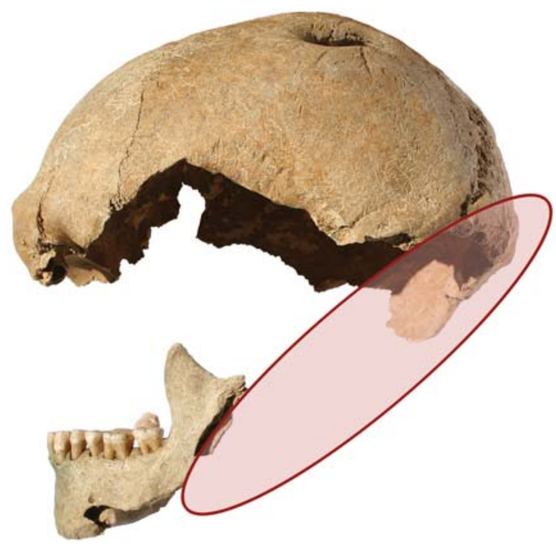

*Fig. 3*. Reconstruction of the plane in which the destructive blows were caused.

*Fig. 4*. Fracture of the mandible, and the directions of the destructive blows.

| | |
|---|---|
| 29. Frontal chord | 101 |
| Frontal subtense | 18.6 |
| 30. Parietal chord | 113 |
| 26. Frontal arc | 119 |
| 27. Parietal arc | 127 |
| 11. Cranial base breadth | 127 |
| 12. Occipital breadth | 128 |
| 45. Bizygomatic breadth | 137 |
| 43. Upper facial breadth | 107 |
| 43 (1). Biorbital breadth | 96.8 |
| Subtense from nasion to biorbital breadth | 11.9 |
| 77. Nasomalar angle | 152.4 |
| 61. Alveolar breadth | 64 |
| 63. Palatal breadth | 35 |
| 67. Anterior mandibular width | 46 |
| 69. Mandibular symphyseal height | 32 |
| 69 (3). Width of the mandibular corpus | 11 |

Nevertheless, the anthropological type of this individual can be broadly characterized based on these data. The horizontal dimensions of the skull are large, the cranial index is 74.5 (dolichocranic), the skull base is wide (it was possible to measure it, owing to the preservation of auricular points). The skull vault's contour is ellipsoid in the vertical norm, while it is intermediate between ellipsoid and tall variants in the lateral norm because of the substantial sagittal curvature of the parietals (the curvature index is 89.0); the vault is roof-shaped in the occipital norm. The contours of the vertical walls of the vault are of trapezoid shape.

The frontal bone is short and narrow with a developed brow-ridge (point 2) and an eminent glabellar region (point 5), weakly bulging (the index of convexity is 18.4), weakly curved (index of curvature is 84.9), and flattened in the transverse section (the angle of transverse curvature of the forehead is 151.8). According to a visual evaluation, the vertical profile of the forehead is sloped. The occiput is wide; the nuchal lines form a massive torus; the external occipital protuberance is moderately developed (point 2).

The facial skeleton is wide and strongly flattened in the horizontal plane at the level of nasion. The lower border of the piriform aperture is of the shape of *sulcus prenasalis*. The anterior nasal spine's development can be described as point 2. *Torus mandibularis* and *maxillaris* are absent. The maxillary alveolar process is of medium breadth, the palate is narrow. The mandibular corpus is average in size. Specific features of this individual include an accessory mental foramen observed just below the main right mental foramen, and the hypodontia of the third lower molars. The upper right third molar is also hypodontic, while at the left side of the maxilla an alveolus of a reduced tooth was identified. The lower right first molar was lost antemortem (removed).

The craniological complex of the individual differs from that of the skulls of the Karasuk culture, while the burial itself might be associated with this culture, judging by its preliminary date and grave goods. Many of the metric variables crucial for racial diagnostics could not be measured in this specimen, including cranial and facial heights, dimensions of the nasal region, and the zygomaxillary angle. Nevertheless, it is undoubtedly more similar to the Mongoloid pattern than to the phenotypically admixed Mongoloid-Caucasoid anthropological types of the Altai-Sayan highlands. Populations of the Andronovo culture were involved in the formation of the anthropological type of the Karasuk population, and this resulted in the generally Caucasoid cranial morphology of the latter. This Caucasoid pattern was, however, "softened" by the influence of the autochthonous substrate of descendants of the Okunev culture, and also by a Mongoloid admixture of Central Asian origin (Rykushina, 2007: 19–20, 91, 123). A stable feature of the cranial morphology typical of populations of the Karasuk culture is the brachycranic cranial vault, while the studied skull is dolichocranic.

The dental traits of the individual that can be used to differentiate his anthropological type are considered below. A remarkable feature is the double shoveling of the upper right medial incisor, expressed as point 3 at the lingual surface (Zubov, 2006: 36) and as point 2 at the vestibular surface (Scott, Turner, 1997: 27–28). This is a reliable marker of the Mongoloid complex (Zubov, 2006: 36). The upper right lateral incisor is barrel-shaped (Hillson, 1996: 19) with a V-shape depression on the vestibular side. The apex of the depression is in the center of the crown at the middle of its height, and its ridges diverge towards the edges of the tooth. A microscopic study revealed no signs of scratches that would have suggested an intentional modification. The upper and lower molars do not exhibit signs of reduction: the development of the hypocone of the $M^1$ and $M^2$ achieves the highest possible point 4, while the metacone is only slightly smaller than the paracone (point 2); the $M_1$ is five-cusped. No styloid formations or accessory cusps were found in the molars. The cervical enamel projection (outgrowth of enamel found between the roots on the vestibular surface of the tooth) is strongly pronounced (point 6) in both upper and lower second molars. In the cases when this trait can be scored as points 5 and 6, it can be used for individual diagnostics (Zubov, 2006: 39). Such diagnostically important traits of the lower molars as the distal trigonid crest and the deflecting wrinkle of the metaconid could not be assessed, owing to a strong dental wear. Nevertheless, the number of cusps and the groove pattern can be scored. The $M_1$ displays a "+" 5 shape, the right $M_2$ "X" 4, and the left $M_2$ "+" 4. Notably, the "+" groove pattern in the first molar is quite often found in Mongoloids (Ibid.: 56), while the "X" and "+" patterns in the second molars are typical of modern humans in general.

The results of the analysis of non-metric dental traits, in accordance with the cranial metric data, seem to confirm the presence of genes of "Eastern" or "Mongoloid" origin in the genome of the studied individual. We do not intend to make far-reaching conclusions and model any genetic relationships based on a study of one fragmentary skull; but we believe it is necessary to point out peculiar features of the skull and find at least some morphological analogies. Those features include a dolichocranic head shape, a visceral eurymorphy, and a horizontally flattened supraorbital region. The morphological complex is complemented with narrow, short, weakly curved, weakly convex, and inclined. Such a combination is not found in the Bronze Age cranial samples of the Altai-Sayan highlands but it has a long history in the circum-Baikal region, going back to at least Neolithic times, and is typical of the Paleosibirian or Baikal anthropological type.

### Use-wear analysis of the trepanation lesion

From the results of the use-wear analysis of traces found on the bone surface around the trepanation lesion, it can be concluded that the craniotomy was performed in two stages. The operation started by making a perforation in the bone by scraping the posterior part of the future aperture (Fig. 5, *a*). The pattern of traces confidently suggests the use of a knife as a surgical tool. The traces are sharp and exhibit characteristic stepped contours, which are similar in terms of kinematics to the traces previously observed on the trepanned skulls of the Pazyryk culture of the Altai Mountains (Chikisheva, Volkov, Krivoshapkin et al., 2014; Krivoshapkin et al., 2014). The anterior part of the aperture was made at the second stage of the surgery (Fig. 5, *b*). The traces on bone point to the use of the same tool, or another tool of the same size, and a "stepped" scraping of bone. The surgical intervention in the second stage probably required faster action by the surgeon during the craniotomy. A tetrahedral tool was used several times in the course of the operation, most probably for the removal of cut-off bone fragments. Traces of that tool are found along the lateral margin of the aperture (Fig. 5, *c*). This could have been an "awl"—the tool widely used in the Late Bronze Age for the removal of stones stuck in horses' hooves. Also, traces of a chisel-like tool with a blunted edge were detected on the surface of the skull, around the trepanation lesion (Fig. 5, *d*, *e*).

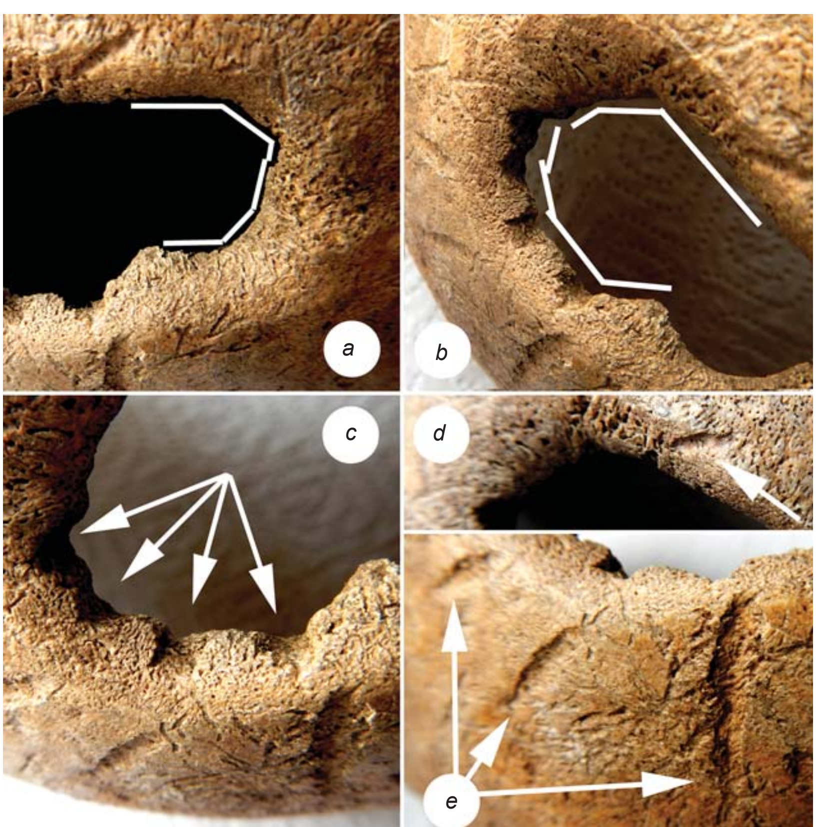


*Fig. 5.* Traces of the first (*a*) and second (*b*) stages of the trepanation, separation of the cut-off bone fragment (*c*), and additional traces in the area affected by the operation (*d*, *e*).

### Differential diagnostics of the trepanation

The penetrating aperture in the area of the left parietal tuber is oval-shaped. The inner plate adjacent to the convexital part of the skull is removed. The maximum internal dimensions of the aperture are 3.4 × 1.8 cm. The edge of the lesion is slightly inclined owing to the removal of a part of the outer plate, so the total size of the lesion is 4.4 × 3.2 cm. A visual assessment reveals that the structure of the outer plate was changed as a result of an inflammatory process, which affected bone posterior to the aperture up to the lambdoid suture. On the surface of the inner plate adjacent to the lesion, the manifestations of the inflammation were spread 2.3 cm anteriorly, 1.3 cm medially, and 2.1 cm laterally.

Multislice computed tomography (MSCT) revealed even more extensive post-inflammatory lesions to the bone that are spread up to the sagittal and coronal sutures, and involve the diploe and both inner and outer plates. A large area of the inner plate is notably thickened: 3.7 and 5.9 cm from the aperture in the direction of the sagittal and coronal sutures, respectively (Fig. 6). The area of apparent post-inflammatory changes is clearly visible on the internal surface of a virtual reconstruction of the skull (Fig. 7). The maximum dimensions of the trepanation lesion are 3.8 cm on the outer plate, and 3.2 cm on the inner plate (Fig. 8, *a*). The edges of the aperture exhibit clear signs of neoplastic change of bone, which is indicative of healing of the wound, and survival of the patient long after the surgery (Fig. 8, *b*). A bone usuration, 1.6 cm long, is observed 0.6 cm from the edge of the lesion (Fig. 8, *c*). Ray-shaped traces of sawing of the outer plate were detected in the parietal bone, below the lateral boundary of the aperture. Two of the rays are visible in a snapshot of the reconstruction (Fig. 9), while a visual examination reveals three saw marks clearly observable in a digital photograph (see Fig. 1, *a*).

The pattern of bone change suggests that the individual had suffered an osteomyelitis of the parietal bone, complicated by an epidural abscess (empyema). The trepanation, during which the affected area was removed and the empyema was emptied, led to the individual's surviving a long time.

An epidural abscess can be triggered by such diseases as acute otitis media or an inflammation in the paranasal sinuses. When combined with an epidural empyema, it is usually the result of a penetrating wound or a surgical intervention. Osteomyelitis of the cranial bones might also be a consequence of a closed

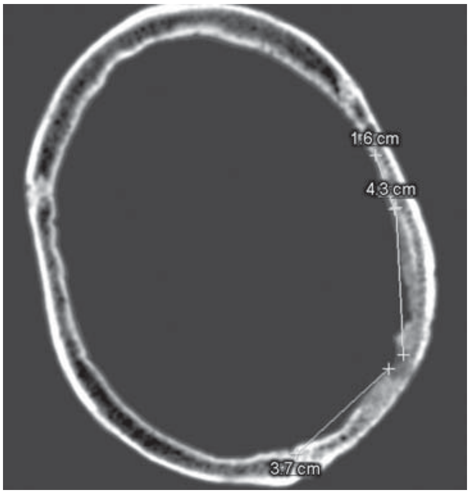


*Fig. 6.* Computed tomography image of the skull: the slice depicting thickening of the inner plate of the parietal bone.

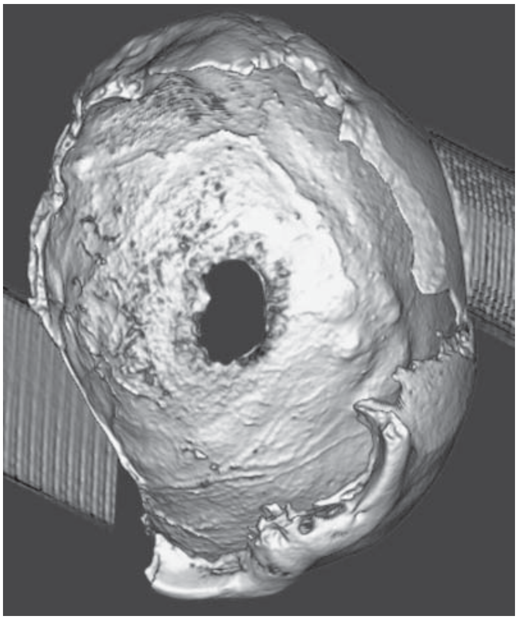

*Fig. 7.* Virtual 3D reconstruction of the convexital part of the skull, showing the spread of post-inflammatory lesions of the bone.

trauma, without penetrating the skin. The development of a hematoma between the periosteum and bone as a result of a blow to the head, and its subsequent infection through the hair follicles, usually lead to the emergence of surface osteomyelitis. In such cases, the sequestration is limited to the outer plate of the skull. But this scenario is rarely observed.

In the case of an open fracture or a surgical intervention, severe osteomyelitis might develop

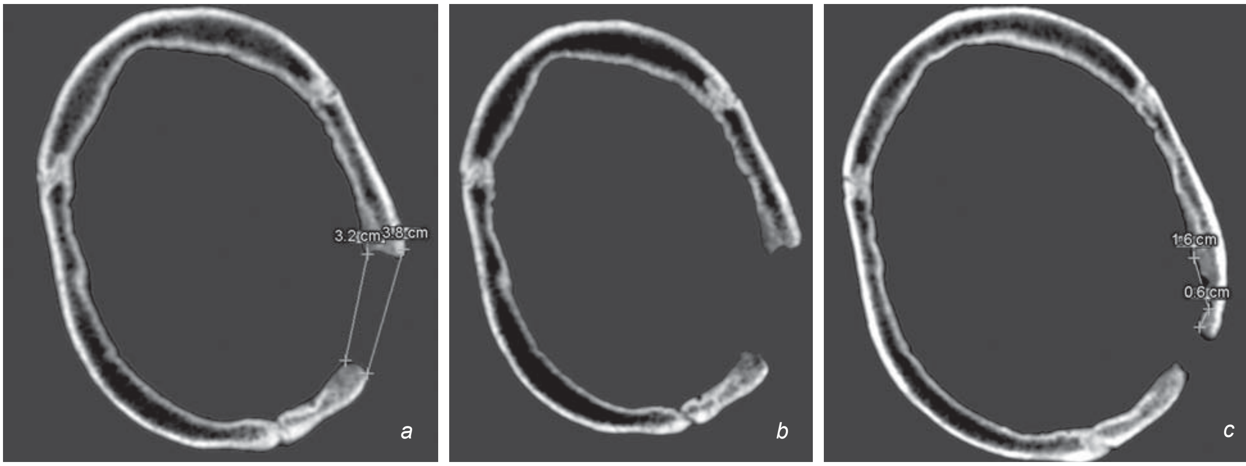


*Fig. 8.* Computed tomography images of the skull: the slices demonstrating maximum dimensions of the trepanation defect (*a*), manifestations of bone neoplasm along its edges (*b*), and signs of bone usurpation (*c*).

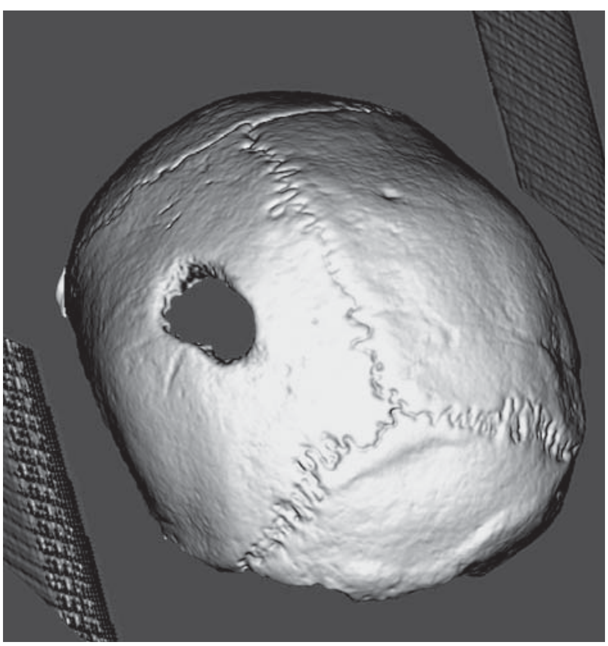

*Fig. 9.* Virtual 3D reconstruction of the skull.

around the lesion. The trauma provokes bleeding into the diploe, and secondary infection of this layer of bone accompanied by thrombophlebitis of the diploietic veins, which leads to disruption of bone supply, necrosis and sequestration of the affected area, and suppuration. The presence of fractures in bone promotes the dispersal of osteomyelitis. Open depressed fractures are particularly often complicated by osteomyelitis and the formation of an epidural abscess, since the wound gets contaminated by pieces of skin, hair, and other infected foreign bodies. The principles of modern neurosurgery require an obligatory revision of the wound in order to remove not only foreign bodies but also fragments of the affected bone.

Sub-acute or chronic progressing osteomyelitis of the cranial bones is clinically difficult when it affects a large area. Fistulas open in the affected skin as a consequence of the sequestration of bone. The bone appears in CT images as a segment with “wormholes” and usuration of bone tissue (see Fig. 8, *c*). The boundary between affected and healthy bone is difficult to delimit. The method of choice for healing in such cases is complete removal of the whole affected region, including the deformed inner plate, up to healthy bone. The epidural abscess should be emptied and drained. If skin is rendered molten by a purulent process, the affected edges of the wound should be segmented. A lasting infectious process is observed in the edges of the bone defect after such an operation, before complete healing.

The epidural abscess manifests as a slowly growing intracranial voluminous body. The disease progresses slowly. Growing headaches, nausea, and vomiting usually appear as a result of increased intracranial pressure. Focal neurological symptoms (motor, sensitive, and speech disorders due to a lesion of the leading brain hemisphere) emerge when adjacent parts of the brain get increasingly suppressed by the purulent content of the abscess. Partial or generalized epileptic seizures may be observed.

Owing to the obscure clinical picture of the epidural abscess, the right diagnosis, even at present, is usually made only when complications, such as oppression of consciousness, or meningeal symptoms, appear. A blowout of the purulent content of empyema through the *dura mater* into the subdural space is also possible, and this is accompanied by a sharp worsening of the patient's condition. However, this scenario is rarely found in practice, as the *dura mater* is a strong barrier against pus drain. Thus, in modern conditions and with the use of antibiotics, the treatment prognosis is positive for the patients after emptying of the epidural abscess.

The visual and CT examination of the studied skull suggests the following reconstruction of the event, which took place three thousand years ago. The man most probably received an open depressed fracture of the left parietal bone as the result of a blow caused by a tool with a small contact area. In modern forensic practice, such "perforated" lesions to the skull are typically caused by hammer-blows. This explains the absence of linear fractures of the parietal bone radiating from the trepanation area. The localization of the lesion is typical for a blow caused by a right-hander. This was followed by an infection to the untreated wound, which led to the formation of bone osteomyelitis (note typical manifestations of bone usuration observed in the CT images), and a contact epidural empyema. A pronounced hyperplasia of the inner plate evidences the long duration of the abscess and its dispersal through a large area above the left brain-hemisphere. The limited change of the inner plate can be explained by the attachment of the *dura mater* close to the sutures. The resection of strongly affected bone tissue and emptying of the abscess resulted in the lasting survival of the patient, as is evident from the healing of the edges of the trepanation aperture.

Judging by the pattern of change in the trepanation area, the ancient surgeon was segmenting bone tissue with an already thickened inner plate. The lower margin of the lesion with squared usurations and the ray-shaped saw marks of the adjacent bone might point towards the use of a thin tetrahedral tool for elevation and removal of infected and depressed bone fragments. It seems that an ancient surgeon three thousand years ago performed a life-saving operation in accordance with modern principles of neurosurgery. The use of bronze tools, which have antiseptic properties, plausibly helped to cope with the far gone infectious process in that pre-antibiotic era.

The account in which the ancient healers carried out a trepanation that led to a severe infectious complication (Slepchenko et al., 2017) is not confirmed by our CT data. Also, this version cannot explain how it was possible to overcome the advanced infectious process.

## Conclusions

The case of trepanation considered in this study is yet one more case of antemortem craniotomy carried out by ancient healers in southern Siberia (Chikisheva, Zubova, Krivoshapkin et al., 2014; Chikisheva, Krivoshapkin, 2017). All these operations are unique in terms of their advisability for the patients: in all cases, serious pathologies were diagnosed, which required intracranial interventions. The summary of the cases of true trepanations studied by the authors of the present study, and comparison of those cases with the data published by other researchers, suggest that the role of the ritual component in the rationale for performing such operations is exaggerated in the scientific and popular literature. At least in southern Siberia, all cases of trepanation described for the time span from the Early Bronze Age to the Early Iron Age (i.e. three thousand years) were life-saving operations due to traumas.

It can be hypothesized that thanks to the use of bronze tools, which have antiseptic properties (Krivoshapkin et al., 2014), the ancient healer was able to cope with a far gone infectious process, which was triggered by an open depressed fracture of the left parietal bone of the male buried in grave 14 at Anzhevka. Modern methods of differential diagnostics revealed that the individual had suffered an osteomyelitis of the parietal bone complicated by an epidural abscess (epyema). The trepanation, accompanied by a removal of the focus of osteomyelitis and emptying of the epyema, resulted in the lasting survival of the individual.

A thorough morphological examination of the remains, aimed at determining what Siberian anthropological type the male could have belonged to, has shown that the closest analogies can be found in the Paleosibirian (or Baikal) anthropological type, which emerged in the circum-Baikal region. On the other hand, some associated grave goods, for instance the bone dagger, find parallels among artifacts of the Karasuk culture. Archaeological research in the Krasnoyarsk-Kansk forest-steppe demonstrates that in the late 2nd to early 1st millennia BC a distinctive archaeological culture was forming in this region. This culture experienced a strong influence from the south and west Siberian cultural provinces (Makarov, 2016). But the influence of east Siberian cultures, which existed in the region during the Neolithic period (Ibid.), was most probably still present in the Late Bronze Age; this is indirectly suggested by the cranial morphology of the studied individual.

Some features of the burial point towards a post-inhumation penetration of the grave and ritual destructive manipulations with the partially skeletonized corpse. It is not possible to conclude definitely if such a ritual was exclusive to this individual or not, until a detailed analysis of all burials of the Anzhevka complex is carried out. Notably, some burials of the complex contain fragmented bones with traces of high-temperature exposure. Such bones were compactly stacked into special pits. Thus, the existence of special post-funerary rites in the Anzhevka population can be hypothesized.

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