

## SPECIAL PAPER

### Cases of Trephination in Ancient Greek Skulls

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#### Abstract

**Background:** Trephination, or trepanning, is considered to be one of the most ancient surgical operations with an especially extensive geographical incidence, both in the New World and in the Old. In Europe, more than 200 finds of trephination have been found, from Scandinavia to the Balkans. The technique of trephination or trepanning covers overall the last 10,000 years and exhibits great versatility and adjustability in the knowledge, technical means, therapeutic needs, prejudices and social standards of each period and of each population group. Hippocrates was the one to classify for the first time the kinds of cranial fractures and define the conditions and circumstances for carrying out a trepanning.

**Aim:** The present research aims to investigate the Greek cranial trephinations on skulls from the collection of the Anthropological Museum of the Medical School of Athens that come from archaeological excavations.

**Method:** Skulls were examined by macroscopic observation with reflective light. Furthermore, radiographic representation of the skulls was used.

**Results:** The anthropological researches and the studies of anthropological skeleton remains that came out during archaeological excavations from different eras and areas have given information about the medical practices in the very important geographic area of Greece and in particular, we referred to cases of Greek trephinations.

**Key words:** trephination, craniotomy, ancient skulls, Hippocrates.

#### Introduction

Trephination, or trepanning, is considered to be one of the most ancient surgical operations with an especially extensive geographical incidence, both in the New World and in the Old (Lisowski 1967, Brothwell 1972, Spanopoulou 1937). Especially in Europe, more than 200 finds of trephination have been found, from Scandinavia to the Balkans.

As far as the time span in the appearance of trephination is concerned, the European finds dated back to the Upper Palaeolithic and Mesolithic period are considered dubious. However, during the Neolithic period, the practice of trephination appears particularly frequent and extensive (Lisowski 1967), including Europe, North and South America,

Africa and Asia (Ksettry et al. 2007). During this period, the percentage of survival of the persons who had sustained a successful trephination operation exceeds 40-70% (Kuehl 1988).

During the Copper era, the trephination finds exhibit an important reduction, in relation to those of the Neolithic period. A fact attributed, on the one hand, to the custom of burning the dead, as a result of which the relevant indications on the skeletal finds of that period were often destroyed. And, on the other hand, to the use of metal weapons which allowed a greater ability to strike vulnerable areas of the body, such as the neck and its vital blood vessels.

While, in the same period, the use of protective head covers of warriors assured a greater protection to the already strong bones of the cerebral skull, preventing the sustaining of cranial injury (Breitinger 1938). In any case, however, the discovery of relevant finds suggests the continuation of the practice of trephination also in the following prehistorical and historical periods, until the Medieval times. In the middle Ages, the classical method of trephination implemented was the one described by Celsus in his work *De Medicina* (25-35 a.D.) (Celsus, 1971). In neighbouring geographical areas, such as south-west Yugoslavia and north Albania, evidence has been found of implementation of trephination to man, but also to pets for a very long time, which extends until the 19<sup>th</sup> cent. (Boev 1959).

In certain areas of the world, the practice of trephination was maintained until our time. Thus, in Kenya, cases of living persons were reported, who had undergone more than one operation of skull opening, in conditions equivalent to those of prehistoric times (Margetts 1967, Lisowski 1967, Brothwell 1972).

During the 18<sup>th</sup> and 19<sup>th</sup> century, trephination operations had been rejected as a therapeutic surgical method, due to the high mortality that reached 100% at that time. This belief was overturned thanks to the progress of microbiology and the use of antiseptic substances, as well as to the discovery of ancient skulls which had sustained trepannings and maintained clear indications of healing of the craniotomy and survival of the person operated.

In Greece the practice of trephination for therapeutic purposes is considered granted at least since the 5<sup>th</sup> cent. b.C. based on relevant reports in the writings of Hippocrates, which reveal that the operation must have been quite frequent in our geographical area (Krug 1984, Lisowski 1967). However, apart from the literary or historical sources, very few verified trephination finds are known from the discovery of relevant palaeoanthropological finds brought to light by archaeological excavations in Greece.

The first researcher who ascertained the existence of ancient trephinations was the famous doctor and anthropologist Paul Broca, in a collection of prehistoric skeletons from central France, dated at 4000-5000 years

Clower, Stanley (2001). The next important verification of the dangerous surgical opening of the skull with primitive means, came from a collection of skulls in Peru with openings, impressive in size and in the frequency of survival of the operated Peruvians (Ksettry et al. 2007).

However, in the beginning of the 2<sup>nd</sup> century, professor Elliot Smith who thoroughly examined, in Cairo, 15,000 Egyptian skulls, was not able to ascertain not even one case of trephination for therapeutic or other purposes (Ksettry et al. 2007).

The technique of trephination or trepanning covers overall, in the greater duration of its implementation, the last 10,000 years and exhibits great versatility and adjustability in the knowledge, technical means, therapeutic needs, prejudices and social standards of each period and of each population group.

Definitely, in the farther prehistoric period, the implementation of trephination must have been with stone tools, mainly of silicate stones which dispose of excellent hardness and form edges with an excellent cutting ability. Much more, and since the Neolithic period and especially in the wider geographical area of the Aegean, volcanic tools must have been used, which disposed of even greater abilities to shape and to serve many uses (as blades, drills, spear-heads, knives, sharpeners, etc.).

The techniques of carrying out trephination with stone tools was with the method of gradually scraping, first the outer plate, then the diploe, and finally the inner plate of the cranial bone. Or with the gradual opening of a circular canal up to the full incision and removal of cranial fragments, avoiding injuring the brain, as well as with the gradual opening of straight canals which created a square or polygon, instead of the circular or elliptic form of the cranial incision.

In the next prehistorical and historical periods, the carrying out of trephination was done with metal tools, either by opening holes of a small diameter in a circular form, which were then connected by cutting the intermediary bone bridges (Steinbock 1976, Lisowski 1967), and with the use of a metal drill with a cylindrical end, which allowed the removal of a disc-shaped section of the cranial bone. This method was established by Celsus (Celsus Cornelius), a famous Roman doctor of the 1<sup>st</sup> cent. a.D., thanks to his classical work “*De Medicina*”, and

met with wide implementation for many centuries. In any case, of the different kinds of trephination implementation, the most frequent was the case of circular opening (Brothwell 1972 Celsus, 1971).

Despite the relevant bibliographical references, it is considered doubtful whether the use of natural anaesthetic substances was wide, i.e. of alcohol, coca leaves, opiate substances and mandrake, during the painful surgical operation of trephination (Ksettry et al. 2007).

Hippocrates (460-370 b.C.), often called the father of Medicine, exceeding the metaphysical beliefs of his predecessors, was able to establish the medical science in the objective observation and logical processing of the data. He was the one to classify for the first time the kinds of cranial fractures and define the conditions and circumstances for carrying out a trepanning (Ksettry et al. 2007).

The classification of cranial fractures by Hippocrates included five categories based on the alterations of the cranial bones, due to the wound:

- Fissured fracture which is always accompanied by a brain hematoma
- Hematoma of the bone, without a fracture
- Depressed trauma of the outer plate, without any damage to the inner plate
- Dinted trauma of the outer plate and fracture of the inner plate by opening the skull
- Indirect fractures as a secondary consequence of direct cranial-cerebral injuries (countercoup injuries (Hippocrates 1988, 1994).

For the interpretation of cranial operations, various causes have been suggested, which refer either to therapeutic purposes to treat injuries, especially cranial fractures, epilepsy, and other conditions, or to treat mental disorders, superstitions and “evil spirits”, or even to serve ritual purposes (Brothwell 1972, Spanopoulou 1937). According to Stewart (1958), the most frequent reason for carrying out a trephination must have been the effort to relieve the brain from endocranial pressure, because of cranial fractures.

In Hippocrates' paper “On Head Injuries”, the opening of the skull is mentioned in the cases of fractures and of cranial bone fragmentation with the purpose of removing bone fragments which penetrated the endocranial space, exerting

pressure to the brain. Finally, in his “Epidemics”, two more cases of trephination for therapeutic purposes are mentioned: that of a young man with a head injury from horse hoof, and of another hit with a stone (Krug 1984).

The operation involved the removal of the soft tissues and revealing of the cranial bone to an extent greater than that of the wound, so as to be able to spot with precision the damages in the bone. For this purpose, a black thick substance could be used, which infiltrated in the fissured fractures of the cranial vault, thus helping to spot and remove bone fragments (Krug 1984).

### **Aim**

The aim of this study is the investigation of the Greek cranial trephinations at the Anthropological Museum of the Medical School of Athens that come from archaeological excavations. In addition, we attempt to shed new light on patients, diseases, and therapeutic interventions of the remote past on the very important geographic Greek Area.

### **Method**

The examination of the skulls took place at the laboratories of the Anthropological Museum of the Medical School of the University of Athens. The method of examination was macroscopic observation with reflective light. Furthermore, radiographic representation of the skulls was used.

### **Material**

#### **The case of a Byzantine skull of Avdira**

The excavation of the extensive Byzantine graveyard in Avdira, the burials of which are dated between the 9<sup>th</sup> and the 11<sup>th</sup> cent. a.D., took place during three excavation periods from 1979 up to 1981 (Sarla - Pentazou 1981). In the framework of the archaeological excavations of the site, on-site works of observation, assembly and maintenance of the anthropological material of the graveyard took place by a crew of the Anthropological museum of the University of Athens.

After the completion of the programmed excavation works, and during the sorting of osteological material from excavations of previous years, a small wooden case was spotted in a site storeroom, which contained, among motley objects, a number of bone finds which were initially considered to be useless

remains of an older work. Later, a more careful observation showed that most of the bone finds were cranial fragments and indeed that they came from the same human skull of a young person (ΕΑΕ1/Σ29).

Specifically, the two parietal bones of the skull, the occipital bone, parts of the two temporal bones, as well as part of the left sphenoid, have been preserved. Along with the above, the first cervical vertebra and four teeth, two canine, one premolar and one molar, have been found and are likely to belong to the same person. Based on the shaping of the bones of the cerebral skull and the lack of synostosis of the cranial sutures, the biological age of the person has been determined at approximately  $22 \pm 5$ . As for the person's sex, based on the limited diagnostic characters preserved, it could with relative certainty be attributed to a young man. However, the most interesting feature of this particular skull constituted the presence of a circular opening (Fig. 1) at the upper right section of the occipital bone, with a vertical diameter of 24mm and a cross-diameter of 21mm, which was considered to be a clear case of trephination. That is, a deliberate and ante mortem operation in the aim of removing part of the flat bones of the skull for the treatment of a serious craniocerebral injury of the young person. An operation known and documented by an important number of relevant finds from all over the world, but also from its implementation on domestic animals which exhibited mostly ambulatory disorders due to encephalopathy /brain disease (Pitsios 1984).



fig-1 Avdiron

In this particular case, the clear and irregular incision of the circular opening showed that it had been carried out with a hand-operated metal cutting tool. Whereas the absence of organic operations of bone healing, in the periphery of the circular incision, suggested the failure of the

operation and the inability of survival of the person.

However, except from the circular opening A at the upper right part of the occipital bone, the examination of the skull also gave interesting data on the conditions of death of the young person (Fig. 2).

Thus, in the left section of the occipital bone and at a distance of 25mm from the left end of the lambdoid suture, the presence of a second and non-completed opening B of the skull was found, which could be owed to an incomplete attempt of a second trephination operation to the same skull as, in the periphery of the bone, fragments of bone tissue in a position of penetration in the interior of the cerebral skull have been preserved. Opening B, of which 2/3 of the round craniotomy is preserved, has a diameter of 20 mm and a morphology same as that of the initial opening A.



fig-2 Avdiron

In addition, at the back third of the sagittal suture and 3cm higher than the lambda, a depressed trauma C has been found which has caused damage to the outer bone plate and a 12x12mm/cm opening to the parietal bones. At that spot, fragments of the outer bone plate of the skull have infiltrated, after an external strike to the interior of the cranial cavity, suggesting a fatal injury, as in the case of opening B.

In the interior surface of the cranial vault, at the spot of the injury, a part of the interior bone plate along with spongy substance has broken off at a surface four times as much (25x23cm) as that of the exterior plate (Fig. 2), a phenomenon characteristic of the structure and mechanical behaviour of the flat cranial bones in cases of skull injuries (Heliakis 1963).

Finally, at the right part of the occipital bone of the person and lower than opening A, a

depressed trauma D with a circular shaping was found which only caused damage to the outer bone plate of the occipital, which was not accompanied by an opening of the cranial bone, equivalent to that of injuries A, B and C. This injury is likely to have been the first and the less painful sustained by the young Avdirite. Whereas the next two, harder hits at the back of the skull, as well as the last one at the top of the person's head must have fatally caused his death.

In any case, the total absence of healing indications in the young Avdirite's multiple craniocerebral injuries shows their temporal and causal correlation with the person's death, which, most possibly, was the result of a violent event and multiple injury of the person which could not be faced by the double trephination operation.

The exceptionally favourable conditions of excavation and preservation of the human skeletal material in the sandy deposits of the Byzantine graveyard of Avdira, contributed to the best possible use of the important human skeletal material, to the study of the physical condition and health of the population, as well as to the thorough recording of the burial customs of that period. We therefore thank once again all the associates of the Komotini Archaeological Museum for the warm hospitality and for facilitating the anthropological work with all available means it had at its disposal.

**The case of a multiple trephination of a skull in Attiki**

In September 2001, during works of classification and maintenance of older collections of the Anthropological museum of the University of Athens, which had been assembled with personal actions of Klonos Stefanos, founder and first Director of the museum from 1886 to 1915, a rare and impressive case of multiple trephination of an ancient skull was spotted.

This skull, on the basis of the data collected, comes from an ancient tomb of Attiki and it must originally have been delivered to the Archaeological Society (under find no. Δ.Y. 65) by an experienced seller of antiquities, around 1871. According to a scientific publication of the 16<sup>th</sup> of February 1871, in the *Pandora* journal, by doctor P. Kallivoursis, it is mentioned, among other things, that this ancient

“operated bone” had been presented by the Secretary of the Archaeological Society of Athens, Mr. Stefanos Koumanoudis, as a rare “part of a human frontal bone found a few months ago in a tomb in Attiki. We have not been able to detect more accurate information”, as indicatively mentioned in the *Pandora* journal.

Specifically, this cranial find is made up of only a large part of the frontal bone and a small fragment of the left temporal one, while it is also accompanied by four teeth, probably of the same person (Fig. 3). These are a premolar and two molars of the lower jaw, as well as two more premolars.

Examining the parts of the cranial sutures preserved and the morphological characters of the part of the frontal and temporal bone, we are led to the conclusion that they belonged to an adult person, possibly male. In addition, if we assume that the teeth belong to the same person (Fig. 6), which is quite likely, then the person's biological age of death, according to Brothwell's method of biological age determination, could be between 25 and 35 years.



fig-3 Attikis



fig-6 Attikis

Yet the main interest of the find lies in the presence of five perfect circular trepannings, of a diameter of 1 cm, opened in the right frontal area of the skull, obviously with a mechanical hand-operated drill (Fig. 4).

It appears, therefore, that, on the Attiki skull with the multiple trephinations, the above process of opening of Celsus' method was implemented, which helps us date the cranial find as later than the 1<sup>st</sup> cent. a.D.

The spatial closeness of cranial openings in the same area of the frontal bone seems to be owed to the spatially specific pathological symptoms of the person and to the vain effort to relieve him, since the absence of indications of healing activity of the bone tissue in the areas of the craniotomies shows that these were done at the same time and without the expected result of survival of the person.



fig-4 Attikis

More specifically, the macroscopic observation of the bone of the cranial husk in the area of the trephinations and specifically between the right frontal area and the coronal suture, shows an osteoporotic corrosion which must be owed to inflammatory workings of the endocranial area from pathological causes. This centered osteoporotic working was also found with an X-ray (Fig. 5).

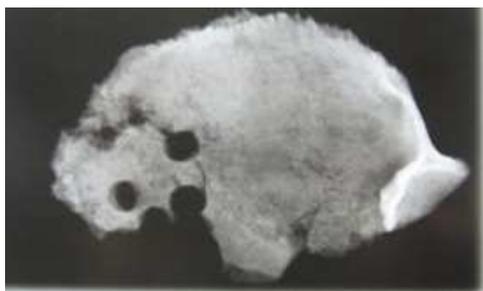


fig-5 Attikis

Thus, it is obvious that these pathological factors acted osteolytically in that particular area of the cranial bone, then causing a process of dissolution of the bone tissue, the consequence of which was the observed porous corrosion of the outer and of the inner bone plate of the frontal bone. The carrying out of multiple trephinations in the same area of the cranial bone obviously aimed at opening the ailing area and removing possible inflammatory elements to relieve the patient.

### Conclusions and Discussion

The anthropological researches and the studies of anthropological skeleton remains that came out during archaeological excavations from different eras and areas have given information about the medical practices in the very important geographic area of Greece. In particular, we referred to four cases of Greek trephinations. In 1971, Angel mentioned the case of skull 33 of the Middle Copper era from Lerna, which bore in the frontal area an irregular and rough opening of the bone with a doubtful interpretation as to its aetiology.

In 1973, the same writer described a case of a very likely, although incomplete, trephination in the frontal bone of skull 51 Myc which belonged to a man of about 28 and came from the royal tombs of Mycenae. The morphology and the dimensions of the cranial opening (30x27mm) resemble those of the skull from Avdira, which we examine. The craniotomy had been done with an especially sharp cutting instrument. According to Angel, the cause of the operation must have been the treatment of a skull injury and fracture. That is, this is a case similar to that of skull XAX1/S29, exhibited at the Anthropological Museum of the University of Athens.

In the year 1982, Angel described two more cases of opening in skulls 49 As and 107 As of the Middle Copper era from Assini, which were characterised by an unusual shaping of the opening of the skull and a doubtful aetiology.

A serious and objective difficulty to diagnose trephination in palaeoanthropological finds constitutes the possibility of openings to the skull, which may be due to either pathological reasons and injuries during the person's live, or to organic and inorganic factors during the time the bones were in the ground or to mechanical damage, before or during the excavation of the

skeletal material (Steinbock 1976, Brothwell 1972).

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