The use of skull trepanation in antiquity has been well documented, and archaeological research has revealed trepanned skulls that date back to the Mesolithic era, some of them bearing evidence of healing. Prehistoric men clearly practiced the procedure, although their motivations in doing so were as likely to have been magico-ritual as they were medical. The general belief is that, in ancient civilizations, trepanation was used as an intervention to treat both head injuries and diseases attributed to supernatural causes.

The earliest written description of trepanation is found in the Hippocratic treatise “On injuries of the head.” Prehistoric men clearly practiced the procedure, although their motivations in doing so were as likely to have been magico-ritual as they were medical. The general belief is that, in ancient civilizations, trepanation was used as an intervention to treat both head injuries and diseases attributed to supernatural causes.

Cranial trepanation is the oldest neurosurgical operation and its roots date back to prehistory. For many centuries, religion and mysticism were strongly linked to the cause of diseases, and trepanation was associated with superstitions such as releasing evil spirits from inside the skull. The Hippocratic treatise “On injuries of the head” was therefore a revolutionary work, as it presented a systematic approach to the management of cranial trauma, one that was devoid of spiritual elements. Unfortunately, there are only a limited number of skeletal findings that confirm that the practice of trepanation was performed as part of Hippocratic medicine. In this historical vignette, the authors present a trepanned skull that was found in Chios, Greece, as evidence of the procedure having been performed in accordance with the Hippocratic teaching. The skull bears a parietal bur hole in association with a linear fracture, and it is clear that the patient survived the procedure. In this analysis, the authors examine the application of the original Hippocratic teaching to the skull of Chios. The rationalization of trepanation was clearly a significant achievement in the evolution of neurosurgery.

Skull of Chios

Despite a rich literary record, there is little in the way of skeletal evidence to confirm that cranial trepanation was indeed performed by Hippocratic physicians. However, a trepanned skull that dates back to the second half of the second century BC was found on the Aegean island of Chios, Greece, and it constitutes one of a very few known skull trepanations that might have been performed under the influence of Hippocratic medicine. The archaeological dig was conducted in the Hellenic necropolis of the island in 2003, by the 20th Ephorate of Prehistoric and Classical Antiquities (Ephorates of Prehistoric and Classical Antiquities are official units supervised by the Hellenic Ministry of Culture, and their authority refers to all matters concerning the discovery, safeguard, and protection of Hellenic heritage).

This was a rescue excavation, in advance of a building project in the present-day city center. The skull (Fig. 1) was unearthed from a cist grave (a box-shaped burial structure made of stone slabs) and belonged to a man who appears not to have been of any special social status as his grave was a simple one, bereft of any offerings or funeral artifacts. The skull bears a round opening, 1.6 cm in diameter, in the left parietal eminence, with a fissure extending from its inferior border down toward the squamous part of the temporal bone. As detailed in an unpublished...
The trepanned skull of Chios

![Image of a trepanned skull with an arrow pointing to the healed linear fracture associated with the bur hole. Copyright Hellenic Ministry of Education and Religious Affairs, Cultural Sector, 20th Ephorate of Prehistoric & Classical Antiquities, Archaeological Museum of Chios. Published with permission.](image)

work (Aidonis A: The trepanation of Chios. The bioarchaeological background of a surgical intervention from the 2nd century BC. Paper presented at the conference “100 years of archaeological research in Chios”, Chios, Greece, October 20, 2012), anthropological study indicated that the opening was the result of trepanation and the fissure very likely represents a healed linear fracture. The edges of the hole are inclined, the slope is not uniform around its perimeter, and the diameter is greater in the external layer. The lack of cut marks from a trephine or a trepan further supports the assumption that the method used was that of scraping the bone. These morphological features favor trepanation, but there are, of course, pathological processes that could be misinterpreted as trepanation such as metastatic carcinoma to the skull, some benign tumors, congenital defects, tuberculosis, or trauma, but none of these processes fit in this case. It is believed that the patient survived several years after the procedure because there is evidence of healing and growth of new bone around the opening, also confirmed by CT. Age estimation of the skeleton indicated that the man died over the age of 50 years.

It is not known, of course, who actually performed the trepanation, and the reason he did so. The trepanation took place approximately two centuries after Hippocrates lived, sufficient time for his teaching to have been disseminated and established, and the skull defect certainly appears to have been made adjacent to a skull fracture, in accordance with his instructions. It is reasonable to assume that the trepanation was performed by a Hippocratic doctor for a head injury. However, the technique was not unique to the Hippocratic physicians, it had already been used for many centuries and non-Hippocratic physicians also practiced medicine across ancient Greece.

The discovery of this skull was covered in the national and international press, and since 2003 it has been exhibited in a prominent position in the archaeological museum of the city of Chios. The following discussion examines the application of Hippocratic teaching on head injuries in association with the trepanned skull of Chios, and compares the rationale behind the ancient practice of trepanation with the principles that govern modern neurosurgery. It is based on a review of the English translation of the Hippocratic treatise “On injuries of the head” by Francis Adams (1849). We have compared the teachings contained in this text to the findings on the skeletal specimen from Chios. We have also tried to assess the therapeutic potential of trepanation in ancient times, based on current scientific knowledge. To the best of our knowledge, this is the first reported case of trepanation performed in accordance with the Hippocratic Corpus.

**Discussion**

The word trepanation comes from the Greek word τρυπάνων (trupanov) meaning trepan, or borer. It refers to the surgical procedure of creating an opening in the skull. Trephination is a more recent word and specifically refers to an opening made by a circular saw (trephine), but both terms are used interchangeably in the literature. The roots of this technique date back to prehistory. Paul Broca and Victor Horsley, both authorities in neuroscience, were among the first to report on ancient trepanned skulls and both proposed theories relating to such primitive cranial surgery. According to Broca’s theory, people believed that the cranial holes allowed the demons causing convulsions to escape. Horsley, on the other hand, suggested that trepanation originated as a way to treat pain and epilepsy caused by skull fractures. Our current knowledge and understanding about this ancient technique derive from saved historical manuscripts of its widespread practice at the time and from bioarchaeological studies of abundant skeletal specimens that have been discovered in many parts of the world.

Cranial surgery in Greece predates Hippocrates by many centuries. The oldest skeletal evidence of trepanation discovered to date was in a Minoan ossuary in Crete (Early Minoan to Middle Minoan period, 2200–1720 BC). Trepanned skulls belonging to different periods have also been unearthed in Delphi (Middle Bronze Age period, 1700–1570 BC), the Peloponnese (Late Helladic period, 1400–1060 BC), Crete (8th century BC), Abdera (7th century BC), and in many other regions, indicating a wide geographic as well as a prolonged chronological distribution. Fabbri et al. presented a case of cranial trepanation that was performed at the beginning of the 5th century BC, in a Greek colony in Sicily. This procedure was evidently performed in the manner that was described a few decades later in “On injuries of the head.” The lack of relevant skeletal evidence in the geographic area of ancient Greece during and after the
Hippocratic era has, however, led some authors to suggest that the practice was not popular among the physicians of that time. Another possible explanation could be that relevant archaeological material has not been studied adequately.

It appears to be the case, then, that the surgical instruments and the technique of trepanation were already known by the Hippocratic era. The contribution of Hippocrates was the stripping of trepanation from superstitions and enabling its conversion into a purely medical procedure. The process paralleled a general transformation of the medical culture at that time to one that became devoid of magico-ritual elements. Hippocrates was the first to apply logic and observation in medical practice. He established medicine as a distinct discipline, bound by a code of ethics, separating it from theology and philosophy. He is thus regarded as the founder of the medical profession. He lived during what is often referred to as “The Golden Age of Classical Antiquity,” in the 5th century BC, when the city-state of Athens flourished politically, economically, and culturally. During this period Hippocrates was an outstanding figure and his practice and teaching revolutionized medicine. The Hippocratic Corpus, a collection of about 60 ancient medical manuscripts, is based on his intellectual work, although none of the texts can be directly credited to Hippocrates himself.

The manuscript “On injuries of the head” is the first written work in history that addresses management of cranial injuries. The author describes the cranium, classifies skull fractures, and proposes a methodical approach to the management of the head-injured patient. This approach starts with a detailed history of the circumstances under which the injury was sustained. The mechanism of injury determines the type of skull lesion that results and is associated with the prognosis. Based on the Hippocratic manuscript, in the skull of Chios that we are considering here, the left parietotemporal linear skull fracture might have been caused by accident or inflicted by a right-handed assailant. In the latter case, the weapon must have been heavy and blunt, rather than light and sharp. The Hippocratic author emphasizes the importance of examining the wound, with inspection and palpation. This examination assesses the condition of the underlying bone and the type of skull injury sustained, to guide management. Regarding treatment with trepanation, the indications were the following: a nondepressed skull fracture (as in this case), bone contusion without fracture, and hedra, a Greek word used to describe a dent in a bone caused by sharp weapons. The author then presents the technique used (described below), emphasizing the importance of maintaining an intact dura mater to ensure a favorable outcome. Finally, the prognosis for a victim of head injury is based on careful evaluation of factors from the patient’s history, together with clinical observation and assessment. Injury to the bregma, for example, carried a worse prognosis as compared with one affecting the occiput. Fall from a height, suppuration of the bone, presence of fever, blisters on the tongue, and presence of contralateral body spasms were all considered dismal prognostic indicators. Overall, the author’s approach to head injuries includes both empiricism and rationalism, which is characteristic of the Hippocratic method and is evident throughout the Corpus.

Trepanation in the Hippocratic era was performed by 3 methods: scraping, sawing, and drilling. The former method, which is the oldest of these techniques, involved the use of a raspatory, which scraped and denuded the bone down to the meninges (Fig. 2 left). It was used when a fracture was present, as on the skull of Chios, or where the bone was thin. Sawing involved the use of a serrated trepan (trephine), which was a metallic, cylindrical, toothed instrument, mounted on a fixed handle and was used to cut a small, circular flap of bone (Fig. 2 center). The depth of the opening and the mobility of the bone flap were assessed with a probe. The cut was not made complete, probably to avoid breaching the underlying dura, and the partly attached bone flap was left in situ, often to fall off on its own. Drilling was performed with a trepan, which took the form of a perforator that was rotated by the string of a bow, thereby creating a circular opening on the skull (Fig. 2 right). During trepanation the instrument was periodically plunged in cold water to dissipate the heat produced by friction.

On the skull of Chios, the location of the bur hole immediately over the fracture in the otherwise solid parietal bone is in accordance with the Hippocratic teaching of scraping down on linear fractures. The bur hole was not made where the fracture intersects the squamosal suture because Hippocrates taught that trepanation over cranial sutures should be avoided. Whether this represents knowledge of the anatomical relationship between cranial sutures and dural sinuses is uncertain. Moreover, the scraping on the skull of Chios did not extend onto the temporal part of the fracture, probably because of a misconception that cutting the superficial temporal artery would

![Fig. 2. The raspatory (left), the serrated trepan or trephine (center), and the trepan (right) were used for scraping, sawing, and drilling, respectively. From Plates 1 and 3 in Adams F: The genuine works of Hippocrates. London: Sydenham Society, Vol 1, 1849.](image-url)
The trepanned skull of Chios

could cause contralateral spasms, which were regarded as a poor prognostic factor. In the case of the Chios skull, it is not known whether there was any associated intracra-
nial injury.

Crani al surgery in antiquity was confined to the scalp, the skull, and the extradural plane. Based on cur-
rent knowledge, therefore, we can question the therapeu-
tic value of trepanation for most head injuries. In modern
neurosurgery, an extradural procedure for trauma is only
used for evacuation of an epidural hematoma or elevation
of a depressed skull fracture, which constitute a minority
of traumatic brain injuries. The purpose of trepanation
according to Hippocrates was to create an outflow pas-
sage for intracranial fluid. Hippocrates does not specify
the nature of the fluid nor the plane, but most authors as-
sume that he was talking about blood, although he may
have meant both blood and CSF. Trepanation also aimed
to prevent abscess formation, as Hippocrates believed
that stagnant blood could become infected.

Our knowledge about the pathophysiology of cere-
bral trauma would predict that trepanation in antiquity
would have been of limited therapeutic benefit. Currently,
many of the injuries the Hippocratic author quotes as
being indications for trepanation are managed perfectly
well conservatively. Furthermore, a depressed skull frac-
ture, arguably the only genuine indication for surgical in-
tervention of the ancient type, was not operated upon in
those times. This was presumably because communica-
tion to the intracranial compartment was already present,
such that “fluids” could escape. In the case of the skull of
Chios, given the rarity of epidural hematomas in middle
age and the limited potential to achieve satisfactory de-
compression through a bur hole, we speculate that the
man might very well have survived anyway, without the
operation he underwent.

Another point of interest is that trepanation was car-
rried out for injuries of the skull without any record of
associated injuries to the brain. Whether this represents
a lack of awareness on the part of the Hippocratic author
of the significance of brain trauma, or whether it was ac-
nowledged in parts of the Corpus manuscripts that have
subsequently been lost, is uncertain. In either case, these
patients were submitted to the risks of what, in those
days, amounted to a major operation, in an era when most
of the principles that govern modern-day surgery were
obviously largely unknown. It was not until the 19th cen-
tury AD that the development of antisepsis substantially
reduced the risks of infection. Sterile surgery provided
safe passage past the barrier of the dura to allow trepana-
tion to serve its therapeutic purposes.

Perhaps most significantly, the practice of cranial
trepanation in antiquity and beyond exemplifies the en-
during needs for humankind to address head injury as a
cause of significant morbidity and death across the
ages. We might reasonably assume that a good survival
rate encouraged the practice and allowed it to continue
throughout history. Hippocrates rationalized the sur-
gical procedure. Moreover, he first described a systematic
approach to the management of head injuries, based on
the empirical knowledge of his time and his own induct-
ive reasoning. He thereby provided an intellectual sub-
strate that influenced medical thought for many centuries
thereafter.

Conclusions

The study of human skeletal remains, in conjunction
with contemporary documents, enriches our understand-
ing of medical practice in ancient times. The trepanned
skull found in Chios illustrates the state of development
of medicine in ancient Greece and sheds some light on
the practice of skull trepanation in Hippocratic medical
culture from the neurosurgical perspective. Moreover,
what the skull shows us validates the theory described in
the treatise “On injuries of the head” and removes some
of the speculations regarding the history of cranial sur-
gery.

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