

Cranial Trephination Surgery in Ancient Times and Archaeological Remains in Israel

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ABSTRACT

Cranial trephination, one of humanity's earliest documented surgical procedures, represents a remarkable intersection of medical practice, ritual belief, and cultural exchange. This study traces the evolution of trephination from the Neolithic through the early medieval period, with particular attention to archaeological and textual evidence from ancient Israel. Drawing on material from Jericho, Lachish, Timna, Akko, Megiddo, Arad, Qarantal, and additional sites, the research demonstrates the persistence of both circular and rectangular trephination techniques. Literary evidence from the Edwin Smith Papyrus, Hippocrates, Celsus, Galen, and Paul of Aegina to the Talmudic Corpus reveals a range of motivations for the procedure, from relieving intracranial pressure after trauma to expelling harmful spirits. Talmudic sources preserve detailed protocols for cranial intervention, including preparatory steps, controlled access to the cranial cavity, and complete removal of offending growths, highlighting parallels between Babylonian and Hellenistic medical traditions. Read alongside the archaeological remains, these texts demonstrate true surgical skill, iterative refinement of instruments, and sophisticated understanding of head injuries and infections. This paper situates trephination at the crossroads of empirical medicine, ritual meaning, and intercultural transmission, illuminating its significance within the broader history and development of ancient neurosurgery and healing traditions in the Eastern Mediterranean.

Keywords: History of Medicine; Cranial Trephination; Neurosurgical History; Clinical Practice; Archaeology of Israel

Introduction

Trephination: Definitions, purposes, and techniques

Trephination (or trepanation) of the human skull is the oldest documented surgical procedure performed by man for which there is archaeological evidence. It derives from the ancient Greek *τρύπανον* [trūpanon], literally “borer” or “auger,” the practice involved creating an opening in the skull through drilling, scraping, cutting, or sawing techniques. It is a surgical intervention in which a hole is made by means of different drilling, attrition and cutting techniques into the human skull [1]. The operation is defined as the removal of a piece of the skull of a living individual without

penetration of the underlying soft tissues. It was performed to relieve pressure caused by intracranial infection, to extract an object embedded in the skull, or to provide a route for harmful spirits to escape. The trephine is an instrument used for cutting out a round piece of skull bone to relieve pressure beneath a surface. Evidence is that the patient could survive for some time after the surgery, since there are indications of healing. If necessary, the procedure could be repeated [2-4]. In examining archaeological records, it becomes evident that trephination was not merely a response to traumatic injuries or medical conditions. It was also deeply entwined with ancient societies' mystical beliefs [5-6].

Since antiquity, four techniques appear to have been used in trephination: scraping away the bone; boring a hole with a drill; making a circular hole with a cutting tool; and cutting or sawing a rectangular hole [7-11].

Trephinations have proven medicinal benefits, and are most often cited in the archaeological literature as curative to head trauma by releasing pressure build up in the head. While these procedures are less frequently linked to curing non-traumatic illnesses and diseases, they have been performed on individuals who had epilepsy, scurvy, chronic frontal sinusitis and ear disease, intracranial disorders and diseases, hydrocephaly, and osteitis [12-16].

Evidence of trephination has been found in prehistoric human remains from Neolithic era onward. The bone that was trephined was kept by the prehistoric people and may have been worn as a charm to keep evil spirits away. Evidence also suggests that trepanation was primitive surgery after head wounds, headache or intracranial problem to remove shattered bits of bone from a fractured skull and clean out the blood that often pools under the skull after a blow to the head. Hunting accidents, falls, wild animals, and weapons could have caused such injuries [17-21].

In ancient times, trepanation instruments were less complex, and were commonly made out of flint, obsidian, or harder material such as stone knives, and later with metal such as bronze and copper. The procedure was done by practitioners utilizing ceremonial knife, sharpened seashells, a trephine drill, and bronze knife [22-24] (Figure.1).

Cranial surgery along history

Trephining has been known in many parts of the Ancient World. Some degree of expertise must have been acquired by military surgeons in the field when they accompanied Assyrian and Babylonian armies on military campaigns. Mention of some actual surgical operations is found in Hammurabi's Code of Laws, in which a knife was used by the physician (âsû) to operate on the patient [25]. Treatment of superficial traumatic lesions was very conservative and operative surgery apparently was rare [26-27].

The Edwin Smith Papyrus (ca. 1650–1550 BC) is the oldest known surgical treatise on traumatic brain injuries and symptoms, which may have been a manual of military surgery. It describes 48 cases of injuries, fractures, wounds, dislocations and tumors. The papyrus contains the first description of the brain, pulsations, and contusions as the result of traumatic brain injury and cerebrospinal fluid, revealing sophisticated knowledge of cerebral anatomy. It is notable for its rational and scientific approach to medicine [28-32].

Hippocrates (460–370 BC) was the first to describe a number of neurologic conditions, many of them resulting from battlefield injuries and gave specific directions on the procedure from its evolution. He argued for trephination in brain contusions but not in depressed skull fractures and cautioned that it should never be performed over a skull suture because of the risk of injury to the underlying meningeal layer. Hippocrates recommended trephina-

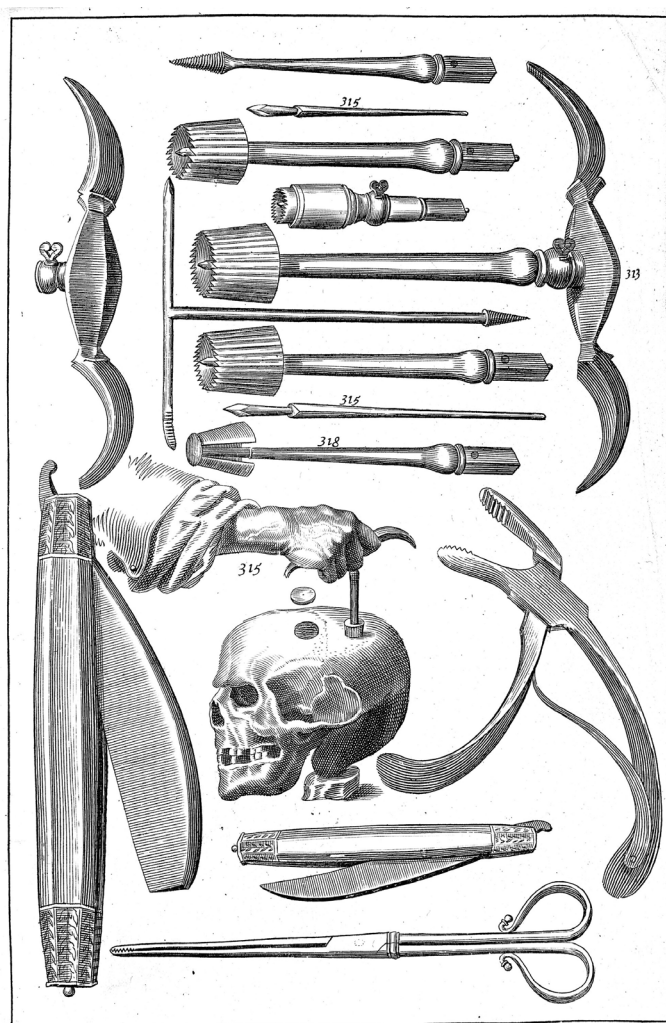


Figure 1. Instruments for trephination. Trephine drills illustrated by the famous chirurgion Ambrose Parey (London, 1634) presented by Sarah Backhouse, exhibition coordinator, 'A hole in the head', Royal College of Physicians Museum, London, 25 October 2013. **Image source:** Wellcome Collection, Image ID: M0016064.

tion for fissured, contused, and dented fractures with contusion or for contusion alone. The theory behind this procedure was the creation of an opening for the excess blood and cerebrospinal fluid that collected underneath. When craniotomy was performed, the crown drill and perforating drill were employed [33-37].

In Greece and Rome, many medical instruments were designed to penetrate the skull. The Roman surgeons developed the terebra serrata, which was made to perforate the cranium by positioning the instrument's pointed end against the cranium and manually rolling the instrument's shaft back and forth between the surgeon's two hands. Both the medical encyclopedist Celsus (ca. 25 BC–50 CE) and Galen (129–216 CE), used these instruments. It is easy to see that the terebra was the forerunner of the manual burr hole, and electric drill neurosurgeons use today for craniotomy procedures [38-41].

Celsus contains a description of an epidural hematoma resulting from a bleeding middle meningeal artery. He sustained that oste-

otomy should be progressive, involving first the external cortex, then the diploid tissue and the internal cortex, paying attention to the meninx, advising the use of meningophylas to protect it, a slightly angulated bronze lamina to be inserted below the bone to be removed, in order to protect the encephalon. The opening of the bone was achieved by a small hammer, by small perforating trephine, or with a large crown trephine [42-45].

Galen provided detailed descriptions of trephination. He described the trephine instrument and the surgical technique, emphasizing the need for precision and caution. His writings on the topic were influential in establishing the procedure as part of a surgeon's toolkit. He was much more liberal about head injury than Hippocrates, arguing for elevation of depressed skull fractures with hematomas and comminuted fractures. He recommended removing of the bone fragments, particularly those pressing into the brain, and provided an extensive description of the safe use of the trephine [45-46]. Galen's accounts of trepanation of the skull are not solely based on second-hand reports but speak of personal experience [47-50].

The Byzantine surgeon Paul of Aegina (625–690 CE) contains a section on head injury and the use of the trephine in his *Medical Compendium*. He developed many tools for clinical cranial surgery and credited as being the first surgeon to have taken advantage of antiseptics, a process that today refers to chemical treatments that kill or inhibit microorganisms. Paul promoted the use of wine to dress the wound after surgery. The wound was dressed with a broad bandage soaked in oil of roses and wine, with care taken to avoid compressing the brain. He was the first to suggest the possibility that an intraventricular hemorrhage might hydrocephalus [51-53].

Scholars sometimes point with justifiable surprise to the evidence that people occasionally survived trepanation surgery [54-56], but never seem to ask whether there was any real medical justification for performing the surgery in the first place [57]. As far as classical antiquity is concerned the procedure is good evidence of the harm that doctors could do [58]. Nearly 60% of the cases described in detail in Hippocratic treatise *Epidemics* ended in death [59].

In 1170 CE the physician Rogerius Frugardi referred to the treatment of head trauma in his treatise *Practica Chirurgiae*. Cranial fractures were treated by perforating adjacent small holes and incising their boundaries to remove the bone. This technique was consistent with the classical approach described by Celsus, Galen, and Paul of Aegina. He encouraged the use of wormwood soaked in rose water and feathers to control blood clotting during trephination [60,52,53]. Thus, nearly 1,000 years prior, the same prescription being used for clinical cranial surgery.

In the Talmudic Corpus (2nd century CE to 12 century CE) there are references to clinical surgical trephination accounts: a physician's drill was described for gaining access to the cranial cavity; tongs were mentioned for the removal of cranial lesions; being used as a treatment for seizure disorders and epilepsy; physicians split the brain; and cases of opened skulls where the wounds were

closed with a dried shell of a pumpkin peel to prevent infection [53,61-64]. The most detailed clinical cranial surgery procedure performed to remove a disease called ra'atan (Babylonian Talmud, Ketuboth 77b) [65]. Its identification is contested. Different ideas were offered: a tumour, meningitis, chronic frontal sinusitis, lupus, or type of leprosy [63,66-71]. The account explains its symptoms, how to prepare the operation place, the recipe, application for an anesthetic, and the process. The use of leaves and tongs illustrates the knowledge that damage to the brain itself would result it probable death so that care was taken to leave both the brain and meninges intact [53,65,70-72]. The concept that ra'atan could have been a chronic frontal sinusitis resulting in a discharging osteomyelitis eroding the anterior and posterior walls of the frontal sinuses is convincing [63,70]. This erosion enabled the removal of pieces of skull by tongs. The pus could have been infested by flies and maggots. The description of the symptoms and etiology demonstrates a strong parallel to Greek medicine [68]. There are also similarities with the Greek surgeon Paul of Aegina [52,60]. Cranial surgery in the Babylonian Talmud is reworking a Jewish-Hellenistic medical idea to suit its Babylonian context by adding instructions for surgery, which contain motifs specific to Babylonian medicine [71,73-75].

Techniques of trephination were known to Jewish physicians in the large medical centre at Alexandria during the Hellenistic-Roman times. Hellenistic Jewish writers would have been familiar with Greek physicians' active in Alexandria and other sites in the Mediterranean. Jews who lived in Hellenized environments may have become physicians themselves by joining schools, becoming apprentices of Greek doctors, and learning medicine by observation and practice [76-79].

Archaeological remains in Israel

There are to date many crania that exhibit this surgical procedure, ranging in time from pre-pottery Neolithic at Jericho (8,350–6,000 BC) to the Early Arab period (8th century CE). The success rate for this form of cranial surgery, based upon inflammatory response or bone remodeling, indicative of post-operative survival, is 77% [80-82].

The first archaeological evidence of trephination in Israel was reported on the recovery of three trephined skulls from 8th–7th centuries BC ossuary at Tell ed-Duweir (Lachish), situated southwest of Jerusalem [8,83-87]. The restudy of male skulls from Lachish provided new confirmation of the multinational population suggested by data from the Bible and excavations at the site. Several skulls bore evidence of angular-notched, rectangular openings, similar to the later Megiddo specimen but on a larger scale. In most cases there was no sign of postoperative healing, indicating that the patients died either during or immediately after the surgery. Three trephined crania with rectangular holes were recovered from a mass grave of Iron Age II (Level III) [88].

Another case of trephination was found in a skull from the Hellenistic–Roman period in Akko in northwest Israel. Details are sparse, but the find demonstrates the continuity of cranial surgery in urban contexts of the north [8,81,87].

Paleopathological profiles of two young adult males, identified as brothers through ancient DNA analysis, were buried together beneath the floor of an elite early Late Bronze Age I (ca. 1550–1450 BC) domestic structure at the urban centre of Tel Megiddo in western Jezreel Valley. Scholars reported that both individuals displayed uncommon morphological variants related to developmental conditions, and each exhibited extensive bone remodeling consistent with chronic infectious disease. One brother had a healed fracture of the nose, as well as a large square piece of bone cut from the frontal bone. The infrequency of trephination in the region indicates that only selected individuals could access such a procedure, and the severity of the pathological lesions suggests the procedure was possibly intended as curative to deteriorating health. Ultimately, both brothers were buried with the same rites as others in their community, thus demonstrating their continued integration in society even after death. Individual 1 had a large square piece of bone removed from the midline frontal bone, atop the persistent metopic suture. The hole measures 32x31 mm at its widest point and was formed by a series of intersecting notches at each corner ranging between 80° and 101°. The instrument used for the procedure appears to have been fine with a sharp beveled edge, leaving clean margins. A small portion of the inner cranial table was still preserved on the upper-right edge. Accompanying the trephination are smaller longitudinal scratches consistent with the opening of the scalp, a necessary step prior to bone excision. The Megiddo example is explained well by this general model for angular-notched trephination. When paired with the pathological appearance of much of Individual 1's remains, the scholars propose that this operation, this operation was meant as an intervention to deteriorating health, but was ultimately unsuccessful [16].

Earlier, in the Middle Bronze Age I (ca. 2200–2000 BC), Jericho yielded several examples of circular trephination. At least three skulls from burial contexts were found with round apertures cut into the cranial vault (Figure 2). Microscopic study revealed partial healing in some cases, suggesting that the individuals survived for weeks or months after the operation [87,89-91]. Later research also reported four trephined skulls in a Roman cemetery near Jericho in the Jordan Valley, although in these cases evidence for survival is less clear. Jericho thus provides the region's best evidence for long-term survival following surgical cranial intervention [92,93].

Four other cases of trephination are known from Azor on the old Jaffa-Jerusalem Road and Arad (Early Bronze Age) west of the Dead Sea (Iron Age), Yavneh-Yam on the southern coastal plain and Qarantal northwest of Jericho (Roman period) [8,90,94,95]. The contexts from Azor and Arad are not as well documented as those from Jericho or Megiddo, but their presence indicates that the practice was already known in the region by the 3rd millennium BC. Concerning the cave near the Qarantal (Deir el Quruntul) contained eight trephined crania, and there is little archaeological data. If the cave can be considered part of the large Jewish cemetery [96], scholars note that it would indicate that trephination was practiced to a limited extent at least by Jews in the Roman period or among the Essenes [76].

A further case comes from near Timna, in the southern Negev, where a trephined skull was uncovered in a tumulus tomb dating from the late Iron Age into the early Roman period (between the 6th century BC and 3rd century CE). The method was again angular-notched, and there was no evidence of healing. The association with a tumulus burial suggests that the deceased belonged to a semi-nomadic or mining-related community in the southern desert. The angular type from Timna is similar to trephination in two skulls from Lachish. It differs from the round trephining found in all Hellenistic Roman specimens. The angular type of trephination appears to have a very low rate of survival, and may have been practiced for ritual rather than for therapeutic reasons [8,82,87,97]. It should be noted that a very different surgical procedure was necessary rectangular trephination, such as appears in the crania from Lachish or Timna than for removing circular roundels (eg, Jericho and Akko). These variations would seem to suggest different reasons for carrying out the procedure [8].



Figure 2. Bronze Age trepanned skull from Jericho showing four separate holes, evidence that people survived this procedure.
Image source: Wellcome Collection, Image ID: L0058402.

A highly relevant case is the trephined skull was found in a burial structure known as nawamis, circular prehistoric stone tombs, located in a large cemetery at Wadi Hebran in south Sinai, 4th millennium BC. The skull was found in a tomb, which contained the remains individuals (five adults and one child). It probably belonged to a male individual, about 35–40 years of age. There is no evidence of disease. Other than the trephination, no pre-mortem injury was noted. The rectangular opening closely resembles later angular-notched techniques found at Lachish, Timna, and Megiddo. The examples strengthen the case for a long-standing regional tradition of cranial surgery [8,98,99].

Conclusion: Trephination across cultures and time

In ancient times, regardless of cultural milieu, physicians appear to have recognized the association between head wounds and increased intracranial pressure, even if their theoretical explanations differed. Several cranial lesions may resemble trephination and must be distinguished from deliberate surgical intervention: age-related parietal thinning that produces natural openings, tumorous processes capable of eroding the skull tables, enlarged parietal foramina, and post-mortem damage. Trephination is still carried out today throughout the world. In modern surgical contexts it serves as a preliminary step in neurosurgery, an emergency procedure to relieve intracranial pressure, or a method for removing or repositioning bone fragments after cranial fractures. In many non-Western societies, trephination is also practiced for broader reasons, including alleviating severe headaches, addressing perceived spiritual imbalance, or providing an exit route for evil spirits. Across millennia, trephination reflects the intersection of empirical surgery, ritual belief, cultural exchange, and evolving medical knowledge from the Neolithic to the early Middle Ages. The combined textual and archaeological evidence from Israel shows that ancient practitioners possessed sophisticated technical skills and a nuanced understanding of cranial pathology. Trephination thus also occupies a central place in the history of medicine and neurosurgery in the Mediterranean Basin.

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