



NEW INSIGHTS ON THE SURGICAL PROCEDURE OF TREPHINATION THROUGHOUT HUMAN HISTORY

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Abstract: *There is an abundance of archaeological and historical evidence from widely disparate localities of the world which indicate that ‘Trephination’/‘Trepanning’ – the removal of a circular portion of the human skull in order to gain access to intracranial maladies that are deemed to require curative treatment – has continued to be practiced down the ages from as far back as 5000 BCE, when flint instruments were used for the required excavation right down to modern neurosurgery. The trepanned skulls unearthed at various archaeological excavations from about the early 19th century, placed under systematic laboratory investigation in recent times, have generated a body of information, an overwhelmingly large proportion of which is ‘case-specific’. The present study, adopting as it does a comparative perspective, and focused exclusively on the cranial drilling component of brain surgery, presents a synthesis of finding from such investigations, selected to provide a spatially and temporally representative range of the practice of trephination.*

Among the insights provided in this study are that: (a) trephinations in Palaeolithic and Mesolithic times were often produced not by cross-cultural transfers of know-how, but were indigenous practices of trial and error, probably ritualistic in origin; (b) as indicated in laboratory findings on crania of pre-historic times, the analyses of calcification along the trepanned edges indicate that post-surgery survival of recipient patients was not entirely non-existent; and (c) in South Asia where the emphasis of traditional systems of curative treatment was on medication, surgery, even on the most delicate parts of the human anatomy, was not excluded.

Keywords: *Trephination, skull, surgery, intracranial, archeological, excavation, ritual*

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Introduction

There is an expanding body of literature based on archaeological and epigraphic research conducted in many localities within the venues of pre-historic civilisations and cultures which indicate that there were various forms of curative health-care practiced by persons recognised in their respective social settings as possessing the required competence. Among these, a surgical procedure referred to as ‘Trephination’ (also spelt as ‘Trepanation’ or ‘Trepanning’) that begins with the removal of a part of the human cranium – usually a circular fragment, as indicated by the etymological derivation of ‘Trepanning’ from medieval Latin and Greek – in order to administer the type of medication deemed necessary for maladies caused by malfunctioning of delicate and sensitive components of the brain. The intracranial corrective measures appear to have been considered attributable to debility and disease caused by accidental or wilful trauma, growth of malignancies, internal haemorrhage, intracranial blood-clots, infections and infestations. In certain settings, traditional healing rites and occult practices are known to have impelled the persistence of trephination.

Surgery involving trephination constitutes the bulk of research findings on curative health care during pre-historic times. This procedure in its most rudimentary form could be described as drilling (or excavating) a hole at an identified spot of the skull surface in order to gain access to the brain. It has been suggested that in several Mesolithic and Neolithic cultures, flint has been used as the instrument of cranial excavation at least as far back as 5,000 to 6,000 BCE. With the passage of time, the instruments used became increasingly refined, thus permitting greater precision and lesser risk of causing unintended brain damage, and reducing pain and tress to the patient (Oakley, *et al*, 1959: 92-96).

The proliferation of archaeological findings of trephination in globally disparate localities in later times could be explained with reference to: (a) the skull invariably being one of the

better preserved parts of the subterranean human remains; and (b) the skull being the largest smooth surface of the human bone-structure which makes it easier to differentiate trephination from other forms of accidental or wilfully damage to the cranium (warfare, torture, primitive ritual, wildlife attacks etc.) than it is in the case of other parts of human skeletal remains. Yet, as made evident below, researchers do not rule out the possibility that trephination was employed in pre-historic cultures for performing surgery in other parts of the anatomy, and with objectives other than curative health-care.

It is appropriate to note here that information generated through archaeological research is invariably more fragmentary and speculative than that derived from other sources of information on the past. It is not difficult to imagine that buried skulls, except in areas where geological formations induce rapid disintegration of organic matter, are ubiquitous. Thus, conclusions on civilisational or cultural patterns of prehistoric trephination derived from excavated crania are featured by an element of speculation and need to be considered as tentative. Moreover, as noted in many authoritative writings (Hawkes & Leonard Woolley, 1963; Mullet-Dietz, 1975), refined techniques of excavation were either not available or ignored by those who dug in search of buried treasures or scholarly fame, especially in the era of European imperial dominance (mainly 19th century), thus destroying much more than what they preserved for subsequent scientific analysis.¹ The fact that world-renowned experts in antiquarian research remained sceptical at least until about the mid-20th century on whether prehistoric trephination was a surgical practice or an occult ritual is indicated from the extract reproduced below. (Hawkes, 1962: 342).

The fact that the scepticism referred to has lingered well into the 21st century is indicated in the following passage (Wylie, 2016).

To date, thousands of skulls bearing signs of trepanation have been unearthed at archaeological sites across the world. But despite its importance, scientists are still not completely agreed on why our ancestors performed trepanation.

Cross-fertilisation of science and technology between ancient civilisations – those of the Mediterranean periphery, Nile, Mesopotamia, Indus and North China – is a phenomenon

observed and documented in major works of research (Caldwell, 1949; Needham, 27 Volumes from 1954 onwards; Huntington, 1996; Ankeri, 2000; Jongko, 2016).² But in prehistoric cultures, mutually isolated as they were, healing rites and technology of curative health-care do not appear to have been fertilised by such civilisational interaction. It is in this context that we observe another intriguing feature relating to trephination – namely, in each prehistoric cultural setting where evidence of trephination has been found, the related procedures appear to be indigenous.

Prehistoric Trephination

Subject to the qualification implicit in the foregoing observations on cranial specimens obtained from prehistoric sites, trephination appears to be associated with the earliest forms of surgery performed in pastoral and farming communities in various parts of the world, invariably in localities close to where the earliest civilisations emerged (Figure 1.1).

The skull with boreholes found by chance in a Neolithic burial ground in the medieval township of Ensisheim located in north-eastern France is probably the oldest of its kind ever discovered. As reported by Amelie Walker (1997), the aforesaid Ensisheim skeletal remains dated between 5,100 BCE and 4,900 BCE, and thus, one of the oldest skulls with evidence of trephination hitherto found. Citing the findings from that skull by a team of researchers at Freiburg University led by Kurt W. Alt, Walker says that it belonged to a 50-year-old man who had been subject to two successive trepanning procedures, one of which had signs of healing along the periphery of the removed fragment of skull, thus indicating that the patient had survived after one bout of trepanation.

There is a far more elaborate modern scientific analysis of a collection of 273 skulls from prehistoric Andean sites located in modern Peru and Chile. Of this collection 47 were found to have been trepanned, in the case of some, at several intervals of time. The male-female proportion of patients was 2:1, with children accounting for



Figure 1.1: This map shows areas (named and bounded by an oval) within which trepanned skulls have been unearthed and placed under intensive scientific scrutiny in recent times as mentioned in the present coverage of published works of research. (See List of References)

7% of the overall total. Additionally, some 70% of these skulls showed signs of healing and other evidence of post-surgical survival.

Such statistics, considered along with the fact that there is no evidence that the ancient Incas made amulets from cranial bones of the deceased, suggest that trepanation was not performed there as a post-mortem ritual. Instead, it had been used for treating health problems associated with intracranial diseases, epileptic seizures, migraines and mental disorders by relieving pressure. Additionally, modern researchers have found evidence that it was used as a form of emergency surgery to remove shattered pieces of bone from fractured skulls after receiving a head wound, and cleaning out the pools of blood that would form within the cranium. Even in pre-Incan Paracas cultures that existed in an area south of the Peruvian city of Lima (Figure 1, inset) skulls recovered from burials show signs of trepanation.

Trepanation in Early Civilisations

The earliest appearance of epigraphic records is generally considered as marking the watershed between ‘pre-history’ and ‘history’ of mankind. With the emergence of the so-called ‘Hydraulic Civilisations’ of the Nile, Mesopotamia, Indus and Hwang Ho basins, such records discovered at archaeological excavations became more numerous. For instance, ‘Bronze Age’ cuneiform tablets from ancient Mesopotamia and papyrus inscription of ancient Egypt are said to record that tools turned out of copper (and its alloy, brass) were used for cranial surgery. With the flowering of these civilisations, brass tools appear to have been replaced with those turned out of iron.

The most detailed records of ancient history on these antiquarian surgical practice available to us at present are those of the Hellenic and Roman empires – especially those authored by the physician Hippocrates (460-370 BCE) and Claudius Galen (2nd century CE). They belonged to different times of the ancient Graeco-Roman civilisations, about 600 years apart. The enormous body of medical learning they have

left behind include their own general contribution to the practice of medicine and to its different aspects such as trepanation. It consists of records of lectures, books, pamphlets and collections of writings by other scholars. Moreover, there are innumerable writings on them and their work, published posthumously by others, up until the present.

Hippocrates’ monograph titled *On Injuries to the Head* described the anatomy of the skull, and the different types of cranial trauma. It identified the type of injury that requires trepanation (such as fissured fractures of the skull, bone contusion) and prescribed the procedures that should be employed, the techniques of intervention, and the tools that should be used, and furnished instructions on medication and other forms of post-surgery patient care. The sketch copied above is said to be based on the collection of articles in Chadwick J. ed. (1984) *Hippocratic Writings*, Penguin, and Symeon (2007).

Claudius Galen, living as he did at a time when trepanation was widely practiced in Europe by surgeons using elaborate equipment of the type not available to surgeons of the pre-Christian era, left behind an even larger body of research writings and other records such as notes taken down by his pupils relating directly to trepanation than Hippocrates. According to Symeon (*op. cit.*) trepanation was used in early medieval Europe especially for the purpose of providing relief of intracranial hematomas in the case of head trauma, and for drainage of phlegmatous lesions of the head. The evidence presently available indicates that, in those parts of late medieval Europe awakening under the impact of the Renaissance, trepanation in its earlier forms was being abandoned in preference to other more refined forms of brain surgery.

Findings based on cranial finding mainly from the Carpathian basin falling largely within the present territory of Hungary indicate that in that part of Eastern Europe trepanning continued to be a surgical practice from Neolithic times up to about the 13th centuries CE. The specimens (4

Neolithic, 10 Copper & Bronze Age, 7 of 4th-6th centuries CE and 11 from 11th-13th centuries) that have been placed under detailed investigation are said to indicate that males and females of all ages (including infants) were subject to this treatment.

There is a paucity of source records that precludes the presentation here of a parallel progress of trepanation in civilisations and cultures such as those of China, the Arab World, Africa the South Pacific islands, Mesoamerica and the Andes in South America. A widely believed general impression that trephination remained alien to China's traditional curative health-care has been dispelled by information obtained from Chinese sources filtered through several English language publications (Leah & Binello, 2017: 451-456; Yawei Zhou *et al.* 2017: Volume 12 (9): 219). These indicate that trepanned skulls have been discovered since the mid-1940s in fairly widely scattered localities of China, and that some among such findings date back to the 3rd to 1st century BCE. They have been dated over a period of about 600 years stretching from Neolithic times well into final stages of the Han Dynasty (2nd Century CE) (Figure 1.3). Scepticism that prevailed in the 'West' regarding the authenticity of these findings – especially on the question of whether they were done with occult rather than medical objectives – appears to have been dispelled by recent publications from China based upon research techniques the results of which are independently verifiable. A brief note on such techniques has been presented later in this article.

Clinical research done on specimens of skulls found in the Melanesian islands located east of New Guinea (Figure 1.2) has indicated that certain tribal communities had practiced trepanning for “magico-medical” reasons. In New Ireland, an island north of New Guinea, a large number of natives had undergone trephination in youth “as an aid to longevity.” It also appears to have been administered as a cure for rheumatism. The fact that practitioners were also priests points to the prevalence of metaphysical objectives such as

exorcising evil spirits.

Detailed clinical studies of skulls from the pre-Columbian cultures of the “New World” recovered from different localities – 20 from Mexico (Oaxacan valley), 10 from Canada (British Columbia) and 8 from the United States – indicate that from about the early centuries of the Christian Era a variety of procedures (mostly cutting and scrapping) and tools (metal, wood, bamboo, shells) were used for the related surgery. According to a synthesised review of these studies conducted by Urcid (2003), there was a remarkably high rate of patient revival. In South America, after the destruction of the Andean Inca Empire by the early Spanish invaders, while the practice of trepanning persisted in the indigenous tribal communities, it has not been subject to detailed study comparable in scientific detail and precision to those conducted on specimen from the pre-historic Andean sites.

Was there Trephination in the Indian Subcontinent?

In the context of the absence of specific references to trepanning in the records of the renowned Indian traditions of medicine – Ayurveda, Siddhi and Unani – and the emphasis placed on pharmacotherapy being a feature common to these traditions, there prevails a general belief that trepanning has remained alien to the medical practices in this vast and culturally diversified area of the Indian subcontinent.

Limitations of space preclude the presentation of an introductory sketch based upon the mass of readily accessible authoritative writings on these medical traditions. Yet, it is necessary to reiterate several sketch basic sets of information in concise form such as:

- (a) There is worldwide acceptance by the cognoscenti of the fact that in certain aspects of curative health care, the aforesaid traditions could have matched or even surpassed in their effectiveness those of the contemporary medical systems elsewhere in the world;



Figure 1.2: The state of preservation of human skeletal remains

Source: Robert Wylie, BBC broadcast (29-08-2016) www.bbc.com/earth

Inset–Source: *Bone Clones*, 2005 <metalonmetal.blogspot.com>

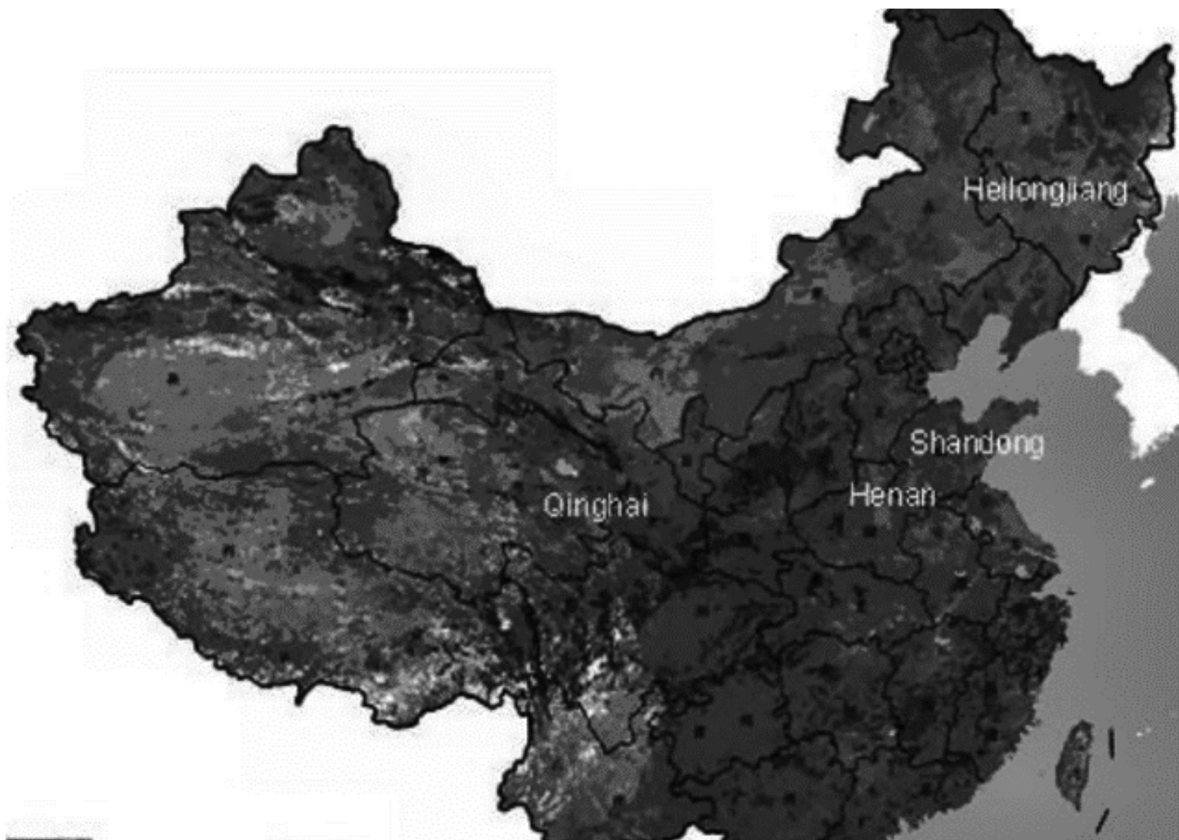


Figure 1.3– Earliest sites of trepanned skulls in China

Source: Leah & Bimello, 2017

- (b) The evolution of these traditions reflect both external influences from beyond the Himalayas as well as their mutual interactions; and
- (c) In most parts of the subcontinent there were religious rituals and occult healing rites that prevailed both alongside as well as outside the purview of these classical traditions.

There is no doubt, however, that in Indian medical traditions surgery was practiced alongside pharmacotherapy, physiotherapy, and dietary control, especially in excision of tumours, incision and draining of abscesses, puncture and release of fluids, extraction of foreign bodies, amputations and resetting of bones. The series of texts referred to collectively as *Sushruta Samhitha*, named after its originator, the 6th century BCE sage Sushruta and subsequently enriched by specialists in the field over several centuries, is said to describe about 300 surgical procedures along with required anaesthesia and instrumentation. As far as it is known to us from the writings presently available, there is no mention in these or other pre-modern texts of operations that involve removal of segments of the human skull or other forms of penetration of the cranium. (Satyan & Weber, 2001: 375-380).³

This brings us to a retrospect of surgery in the traditional practices of medicine in Sri Lanka the scholarly contents of which were drawn largely from *Siddhāyurveda* – a blend of the medical traditions in northern and southern parts of India. On this the most important source presently available is the invaluable treatise titled *Sinhalese Materia Medica* by John Attygalle (1917).⁴

That medicine and surgery were promoted and sponsored by the Sri Lankan monarchs at least from the reign of Pandukabhaya (c. early 3rd century BCE) has been recorded in the 5th century chronicle, *Mahavamsa* and its follow-up chronicles the *Chulavamsa*. These and other records of the early history of Sri Lanka also indicate that the royal contribution to the practice of medicine in his domain by King

Buddhadasa (337-365 CE) surpasses that of any other. Buddhadasa, a uniquely erudite scholar, a traveller in pursuit of knowledge, a friend of the famous Kalidasa of India whose literary creations have acquired worldwide fame and, above all, a reputed physician and surgeon whose *Sārārtha Sangrahaya*, written in Sanskrit, is Sri Lanka's oldest compendium of medicine and surgery hitherto found. In the writings on this unique monarch there are references to surgery which the king himself performed, one of which, as narrated by a monk, involved an infestation from the brain. As to whether this involved any form of trepanning is not known.⁵

Laboratory Analysis of Trepanned Skulls

The study led by Mario Caric (2020) based primarily on an analysis of three Bronze Age trepanations obtained from an archaeological site in Croatia also contains a synthesis of findings from several other sources of laboratory analysis on aspects such as the post-trepanation survival rate of patients, their age, gender, and the likely cause for which this form of surgery was conducted. The analyses referred to is focused mainly on osseous regeneration along the edges of the skull from which the cranial fragment had been removed (Figure 1.2, inset), either by drilling or by dredging with a surgical utensil. Ossification is known to commence microscopically within several days after the trepanning procedure. If the analyst finds that traces of ossification identifiable in laboratory study are completely absent, it indicates that the patient died shortly after trepanation. If there had been continued ossification inwards towards to hole, specimens from that bone-regeneration enables the determination of the patients' post-trepanation survival, and other types of information referred to above through procedures that involve both correlative studies on comparable investigations elsewhere as well as relevant information on the archaeological site.

In current day neurosurgical practice, burr holes, trephine craniotomy, mini craniotomy and

extensive craniotomy are the means of access for intracranial structures. What was meant by trephination in the past may very well have encompassed all above procedures. A burr hole is the smallest access for intracranial structures, a hole made with a special drill bit and is used for -biopsy, monitoring of intracranial pressure, draining of an abscess, evacuation of a chronic Subdural haematoma and extra-dural haemorrhage, formation of a ventriculo-peritoneal shunt and elevation of a depressed fracture. Exploratory burr holes were of particular use up-to very recent times till advanced imaging techniques became freely available, especially in under-developed neurosurgical setups. In situations with a suspicion of an extra-dural haemorrhage, in a patient with a depressed fracture who was deteriorating, aspiration of the bleeding through a burr-hole was a standard treatment. An extensive or mini craniotomy which is an opening into the cranial cavity is used for excision of tumours and aneurysm clipping. Trepanning in modern day neurosurgery is performed through a port which in size is between a burr hole and an extensive craniotomy.

Hence in modern neurosurgical practice, trepanning is still an important procedure used for both therapeutic and exploratory purposes. It is also used as a port of access for introduction of a stereotactic probe into the brain. Thus trephination is one of the longest running surgical procedures practiced in human medical history.

Notes

1. In many parts of the British Empire, especially in Africa and in Southeast Asia, “digging for treasures” had official sponsorship from the colonial bureaucracy. In Sri Lanka, even when archaeological research led by pioneers such as J. C. Smither, P. Goldschmidt, and H. C. P. Bell and began to be impelled by genuine antiquarian scholarship in the latter half of the 19th century, Archaeology took the form of ‘*Exploration*’ rather than ‘*Excavation*’. Scientific excavation, as shown in several writings by one of Sri Lanka’s most eminent archaeologists Siran Deraniyagala, credited as the pioneer in the use of modern procedures of excavation, that are easily accessed through the Internet.

2. Since there is an abundance of scholarly works on this subject, easily accessed in websites, it would be redundant to cite sources from which these generalisations have been derived.
3. The sketch made in this paragraph is based on series of recent publications by reputed neurosurgeons (Banergee, Ezra & Nanda, 2011; Misra & Singh, 2017, all of which are cited in Reddy, Raja & Satyamurthy, 2019: 639-642) indicate that evidence on India’s great surgical tradition is derived mainly from literary sources.
4. John Attygalle, MD (Aberdeen), MRCS (England), Colonial Surgeon Major, was an extraordinarily gifted scholar whose treatise was based on consultation of publications on medicine and surgery in both India and Sri Lanka – the latter including medieval works such as *Saratha Sangrahaya*, *Manjuse* (7th century) and *Yogarātnākara* (12th century), and extensive field investigations.
5. The main source for the information furnished here is Attygalle (1917), referred to above. Several others have also borrowed from the same source some of this information.

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