

## Chapter 22

# Trepanation from the Palaeolithic to the Internet

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### *Abstract*

The oldest known surgical procedure is trepanning or trephining, the removal of a piece of bone from the skull. It was practiced from the late Palaeolithic period and in virtually every part of the world. It is still used in both Western and non-Western Medicine. We consider the methods and motives of trephining in different times and cultures.

**Keywords:** Trepanning, Trephining, History of neuroscience, Hippocrates

## A Peruvian Skull

In 1865, in the ancient Inca city of Cuzco, Ephraim George Squier, explorer, archeologist, ethnologist and lately US *charge d'affaires* in Central America, received an unusual gift from his hostess, Señora Zentino, a woman known as the finest collector of art and antiquities in Peru (Squier, 1877). The gift was a skull from a vast nearby Inca burial ground. What was unusual about the skull was that a hole slightly larger than a half-inch square had been cut out of it. Squier's judgement was that the skull hole was not an injury but was the result of a deliberate surgical operation known as trepanning and furthermore, that the individual had survived the surgery (Squier, 1877).

When the skull was presented to a meeting of the New York Academy of Medicine, the audience refused to believe that anyone could have survived a trepanning operation carried out by a Peruvian Indian (NY Acad Med, 1865). Aside from the racism characteristic of the time, the skepticism was fueled by the fact that in the very best hospitals of the day, the survival rate from trepanning (and many other operations) rarely reached 10%, and thus the operation was viewed as one of the most perilous surgical procedures (Lisowski, 1967; Majno, 1975; Bakay, 1985). The main reason for the low survival rate was the deadly infections then rampant in hospitals. Another was that the operation was only attempted in very severe cases of head injury.

Squier then brought his Peruvian skull to Europe's leading authority on the human skull, Paul Broca, Professor of External Pathology and of Clinical Surgery at the University of Paris and founder of the first anthropological society. Today, of course, Broca is best known for his localization of speech in the third frontal convolution, "Broca's

area", the first example of cerebral localization of a psychological function, but at this time his fame seems to have been primarily for his craniometric and anthropological studies (Schiller, 1992).

## Broca and More Skulls

After examining the skull and consulting some of his surgical colleagues, Broca was certain that the hole in the skull was due to trepanation and the patient had survived for a while. But when, in 1876, Broca reported these conclusions to the Anthropological Society of Paris, the audience was also dubious that pre-Columbian Peruvians could have carried out this difficult surgery successfully (Schiller, 1992).

Seven years later a discovery was made in central France that confirmed Broca's interpretation of Squier's skull, or at least, demonstrated that "primitives", indeed Neolithic ones, could trepan successfully. A number of skulls in a Neolithic grave site were found with roundish holes two or three inches wide. The skulls had scalloped edges as if they had been scraped with a sharp stone. Even more remarkable, discs of skull of the same size as the holes were found in these sites. Some of the discs had small holes bored in them, perhaps for stringing as amulets. Although some of the discs had been chiselled out after death, in most cases, it was clear from the scar formation at the wound's edge that the interval between surgery and death must have been years. Trephined skulls were found of both genders and of all ages. Virtually none of the skull holes in this sample were accidental, pathological or traumatic. Furthermore very few of the skulls showed any sign of depressed fractures, a common indication for trepanning in modern times (Schiller, 1992; Sigerist, 1987).

These findings finally established that Neolithic man could carry out survival trepanation but left open the motivation for this operation. At first, Broca thought that the practice must have been some kind of religious ritual, but later he concluded that, at least in some cases, it must have had therapeutic significance (Schiller, 1992; Sigerist, 1987).

Broca actually wrote more papers on prehistoric trepanation and its possible motivation than he did on the cortical localization of language (Schiller, 1992). Since Broca's time, thousands of trepanned skulls have been found and almost as many papers written about them (Lisowski, 1967; Margetts, 1967). They have been discovered in widespread locations throughout every part of the world in sites dated from the late Palaeolithic to this century. The usual estimates for survival of different samples of trepanned skulls ranges from 50% to 90% with most estimates on the higher side (Lisowski, 1967; Margetts, 1967; Saul and Saul, 1997).

## Methods of Trepanning

Across time and space five main methods of trepanation were used (Lisowski, 1967; Saul and Saul, 1997). The first was rectangular intersecting cuts as in Squier's skull (Fig. 1). These were first made with obsidian, flint, or other hard stone knives and later with metal ones. Peruvian burial sites often contain a curved metal knife called a tumi,

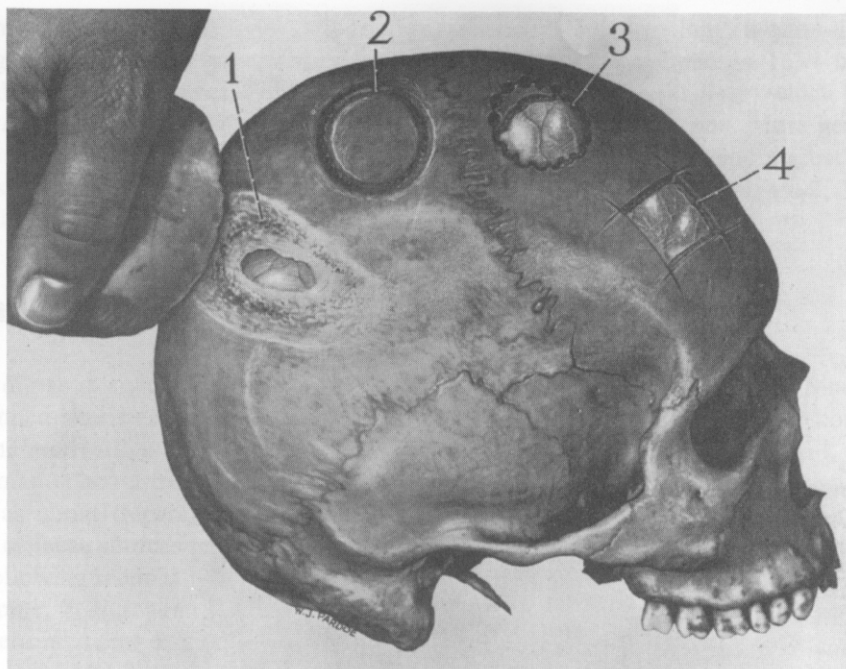


Figure 1. Different methods of trepanning. 1. scraping 2. grooving 3. boring and cutting. 4. rectangular intersecting cuts (Lisowski, 1967).

which would seem to be well suited for the job. (The *tumi* has been adopted by the Peruvian Academy of Surgery as their emblem). Besides Peru, skulls trepanned with this procedure have been found in France, Israel and Africa.

The second method was scraping with a flint as in skulls found in France and studied by Broca. Broca demonstrated that he could reproduce these openings by scraping with a piece of glass, although a very thick adult skull took him fifty minutes "counting the periods of rest due to fatigue of the hand" (Schiller, 1992, p.160). This was a particularly common method and persisted into the Renaissance in Italy.

The third method was cutting a circular groove and then lifting off the disc of bone. This is another common and widespread method and was still in use, at least until recently, in Kenya.

The fourth method, the use of a circular trephine or crown-saw, may have developed out of the third. The trephine is a hollow cylinder with toothed lower edge. Its use was described in detail by Hippocrates (Hippocrates, 1999). By the time of Celsus, a first-century Roman medical writer, it had a retractable central pin and a transverse handle and looked almost identical to the modern trephine and to many of the trephines used in western medicine in the intervening periods (Wilkins, 1997; Thompson, 1938) (see Fig. 2).

The fifth method was to drill a circle of closely spaced holes and then cut or chisel the bone between the holes. A bow may have been used for drilling or the drill simply

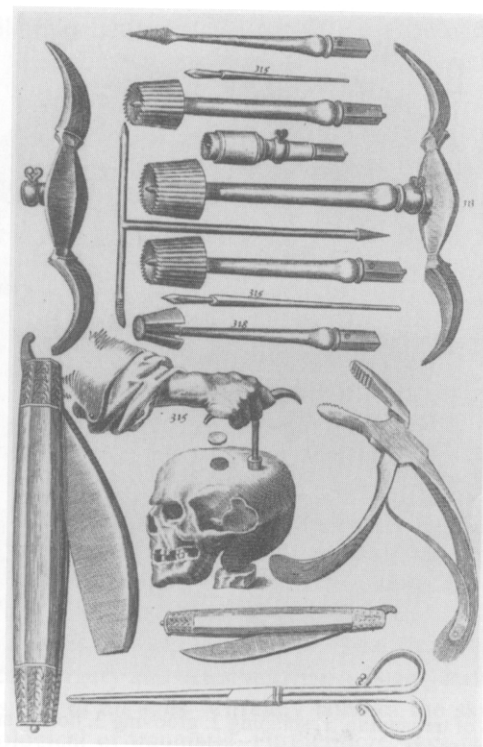


Figure 2. A seventeenth-century naval surgeon's trepanation kit (Woodall, 1639). The trepans are very similar to both ancient Roman and modern ones (Wilkins, 1997).

rotated by hand. This method was recommended by Celsus, adopted by the Arabs and became a standard method in the Middle Ages. It is also reported to have been used in Peru and, until recently, in North Africa. It is essentially the same as the modern method for turning a large osteoplastic bone flap in which a Gigli saw (a sharp edged wire) is used to saw between a set of small trepanned or drilled holes.

## Trepan v Trephine

The relationship between the terms "trepan" and "trephine" is a curious one. The terms are now almost synonyms but have different origins and once had different meanings. In Hippocrates's time the terms *terebra* and *trepanon* (from the Greek *trupanon*, "a borer") were used for the instrument that is very similar to the modern trephine. In the sixteenth century Fabricius ab Aquapendente invented a triangular instrument for boring holes in the skull (he was Harvey's teacher and the discoverer of venous valves). It had three arms with different shaped points. Each of the ends could be applied to the skull using the other two as handles. He called it a "tres fines" from the Latin for three ends, which became *trafine* and then *trephine*, and by 1656 it was used as a synonym for *trepan*, as



a term for the older instrument. In another version of the etymology, a quite different triangular instrument for boring a hole in the skull was invented in 1639 by John Woodall, a London surgeon, who also called his instrument a *tres fines*, which became *trefina* and then *trephine* and again, eventually a synonym for *trepan*. More generally, in Renaissance times and later, trepanation was a popular operation and a great variety of instruments for carrying it out were invented (Bakay, 1985; Wilkins, 1997; Thompson, 1938; Mettler and Mettler, 1945).

## Why Trepan?

Why did so many cultures in different periods cut or drill holes in the skull? Since most trepanned skulls come from vanished non-literate cultures, the problem of reconstructing the motivations for trepanning of these cultures is a difficult one. However, there is information about trepanning in Western medicine from the fifth century BC onwards as well as about trepanning in recent and contemporary non-Western medical systems. Both of these sources may throw light on the reasons for the practice in earlier times. In the following sections we consider trepanation in Hippocratic medicine, in ancient Chinese medicine, in European medicine from the Renaissance onwards, in contemporary non-Western medicine and on the internet today.

## Hippocratic Medicine

The earliest detailed account of trepanning is in the Hippocratic corpus, the first large body of Western scientific or medical writing that has survived. Although there is no question that there was a famous physician called Hippocrates in the fifth century BC, it is not clear which of the Hippocratic works were written by him. The most extensive discussion of head injuries and the use of trepanning in their treatment is in the Hippocratic work *On Wounds in the Head* (Hippocrates, 1999).

This treatise describes five types of head wounds. Interestingly, however, the only type for which trepanation is not advocated is in cases of depressed fracture. Even when there is not much sign of bruising, drilling a hole in the head is recommended. The trepanning instrument was very similar to the modern trephine, except that it was turned between the hands or by a bow and string rather than a crosspiece. The Hippocratic writer stressed the importance of proceeding slowly and carefully in order to avoid injuring the [dural] membrane. Additional advice was:

When trephining it is necessary to remove the trephine frequently on account of the heat transmitted to the bone and dip it in cold water...and guard against careless application of the trephine, and always fix the trephine firmly at the site where the bone seems thickest, inspecting it frequently, and try, by rocking it back and forth, to lift the bone out. (Hippocrates, 1999, p. 91)

Trepanning over a suture was to be studiously avoided.

Apparently the Hippocratic doctors expected bleeding from a head wound and the reason for drilling the hole in the skull was to allow the blood to escape: "If the bone has suffered any of these injuries [crush-injury or fracture], let blood escape by perforating the bone with a small trephine, taking care to check at short intervals, for the skull of young people is thinner and has less depth than that of older persons" (Hippocrates, 1999, p. 87). Since they presumably had no notion of intracerebral pressure, why did they want the blood to run out? Although the reasons for trepanning are not discussed in *On Wounds in the Head*, they seem clear from other Hippocratic treatises such as *On Wounds* and *On Diseases*. The Hippocratic doctors believed that stagnant blood (like stagnant water) was bad. It could decay and turn into pus. Thus, the reason for trepanning, or at least one reason, was to allow the blood to flow out before it spoiled. In cases of depressed fractures, there was no need to operate since there were already passages in the fractured skull for the blood to escape (Majno, 1975).

## Trepanation in Ancient China

The possibility that trepanation was practiced in ancient China is suggested by the following story about Cao Cao and Hua Tuo from *Three Kingdoms*, a historical novel attributed to Luo Guanzhong (Guanzhong, 1991), written in the Ming dynasty (1368–1644) and set in 168–280 at the end of the Later Han dynasty. Cao Cao was commander of the Han forces and posthumously Emperor of the Wei dynasty and Hua Tuo was a famous physician of the time whose works but not fame have disappeared (Lu and Needham, 1980).

...Cao Cao screamed and awoke, his head throbbing unbearably. Physicians were sought, but none could bring relief. The court officials were depressed. Hua Xin submitted a proposal: "Your highness knows of the marvelous physician Hua Tuo? ...Your highness should call for him"...

Hua Tuo was speedily summoned and ordered to examine the ailing king. "Your Highness's severe headaches are due to a humor that is active. The root cause is in the skull, where trapped air and fluids are building up. Medicine won't do any good. The method I would advise is this: after general anesthesia I will open your skull with a cleaver and remove the excess matter, only then can the root cause be removed." "Are you trying to kill me?" Cao Cao protested angrily ...[and]... ordered Hua Tuo imprisoned and interrogated....

Ten days later Hua Tuo died...his medical text was lost upon his death... (Guanzhong, 1991, p. 591)

## Western Medicine

From the Renaissance until the beginning of the nineteenth century trepanning was widely advocated and practiced for the treatment of head wounds (Lisowski, 1967; Bakay, 1985; Mettler and Mettler, 1945; Goodrich, 1997; Dagi, 1997; Wehrli, 1939). The most common use was in the treatment of depressed fractures and penetrating head

wounds. However, because of the high incidence of mortality, particularly when the dura was penetrated, there was considerable debate in the medical literature throughout this long span about when and if to trephine (Dagi, 1997). Besides trepanning in cases of skull fracture, the Hippocratic practice of "prophylactic trepanation" in the absence of fracture after head injury continued to persist. For example, in the 1800s, Cornish miners "insisted on having their skulls bored" after head injuries, even when there was no sign of fracture (Rosen, 1939, p. 197).

Until the early nineteenth century trepanation was done in the home (Fig. 3). However, when the operation was moved to hospitals, the mortality was so high that trepanation for any reason, including treatment of fractures and other head injury, declined precipitously (Bakay, 1985). The practice was so dangerous that the first requirement for the operation was said to be "that the wound surgeon himself must have fallen on his head" (Majno, 1975, p. 28) or, as Sir Astley Cooper put it in 1839, "if you were to trephine you ought to be trephined in turn." (Dagi, 1997, p. 302). It was against this background that the discovery of Neolithic trepanning was so unbelievable to the American and French medical communities in the middle of the nineteenth century. Eventually, the introduction of modern antisepsis and prophylaxis of infection at the end of the nineteenth century as well as an increased understanding of the importance of intracerebral pressure in head injury, allowed trepanation to return as a common procedure in the management of head trauma (Dagi, 1997).

In modern neurosurgical practice, trepanning is still an important procedure but it is no longer viewed as therapeutic in itself. It may be used for exploratory diagnosis, for relieving intracerebral pressure (as from an epidural or subdural hematoma), for debridement of a penetrating wound, and to gain access to the dura and thence the brain itself (for example, to provide a port, through which a stereotactic probe can be introduced into the brain).

## Epilepsy and Mental Disease

In the European medical tradition, in addition to its use in treating head injury, trepanning has been an important therapy for two other conditions, epilepsy and mental illness. The tradition of trepanning as a treatment for epilepsy began as early as Aretaeus the Cappadocian (ca 150), one of the most famous Greek clinicians (Aretaeus, 1856) and lasted into the eighteenth century (Temkin, 1971). The thirteenth-century surgical text *Quattuor magistri* recommended opening the skulls of epileptics "that the humors and air may go out and evaporate" (Temkin, 1971, p. 235). However, by the seventeenth century trepanation for epilepsy was beginning to be viewed as an extreme measure as in Riverius' *The Practice of Physick* (1655):

If all means fail the last remedy is to open the fore part of the Skul with a Trepan, at distance from the sutures, that the evil air may breath out. By this means many desperate Epilepsies have been cured, and it may safely done if the Chyrurgeon be skilful." (Temkin, 1971, p.235)

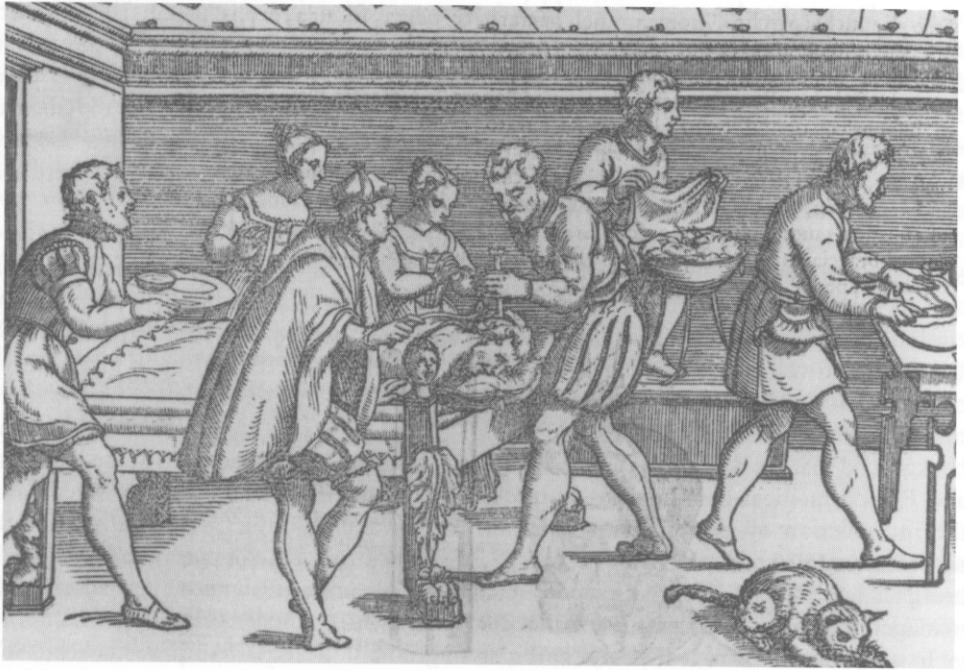


Figure 3. A sixteenth-century woodcut of a trepanation in the home. Note the man warming a cloth dressing and the woman praying (Dagi, 1997).

By the eighteenth century the incidence of trepanning for epilepsy had declined and its rationale changed. Now rather than the previous idea of allowing an exit for evil vapors and humors, the purpose was to remove some localized pathology. By the nineteenth century trepanning for epilepsy was confined to the treatment of traumatic epilepsy, that is, cases associated with known head injury (Temkin, 1971).

Another use of trepanning was as a treatment for mental disease. In his *Practica Chirurgiae*, Roger of Parma (ca. 1170) wrote:

For mania or melancholy a cruciate incision is made in the top of the head and the cranium is penetrated, to permit the noxious material to exhale to the outside. The patient is held in chains and the wound is treated, as above, under treatment of wounds." (Mettler and Mettler, 1945, p.16)

Robert Burton, in his *Anatomy of Melancholy* (1652), also advocated boring a cranial hole for melancholy:

Tis not amiss to bore the skull with an instrument, to let out the fuliginous vapors...a melancholy man at Rome, that by no remedies could be healed, but when by chance he was wounded in the head and the skull broken, he was excellently cured...Guinerius cured a nobleman in Savoy by boring alone, leaving the hole open a month together by means

of which, after two years melancholy and madness, he was delivered. (Burton, 1652, p. 450)

The great Oxford neuroanatomist and physician Thomas Willis (1621–1675) believed that “threatening, bonds or strokes” were “Curatory” for Mad-men but noted that “Specifick Remedies such as St. Johns-wort as well as Chirurgical Remedies such as Trephining or opening the skull” have been recommended (Willis, 1683, p.192–3).

## Trepanning in Flemish Art

Probably the most famous depiction of trepanning for mental disease is Hieronymus Bosch's (1450–1515) *The Cure for Madness (or Folly)*, also known as *The Stone Operation* (Fig. 4). This painting shows someone making a surgical incision in the scalp. The inscription has been translated (Cinotti, 1969) as “Master, dig out the stones of folly, my name is “castrated dachshund.”” This is usually interpreted as reflecting a contemporary belief that folly, stupidity and madness were due to stones in the head. “Castrated dachshund” was an epithet for a simpleton (Cinotti, 1969; Gibson, 1973; Harris, 1995; Bax, 1979; Schubach, 1978).

The art-historical literature is replete with a large number of conflicting interpretations of the details of this painting such as the role of the two on-lookers, the funnel on the surgeon's head, the book on the woman's head, the fact that a water tulip, not a stone, is being extracted from the head, the gibbet in the background and other puzzling aspects. In spite of the disagreement on the meaning of the various apparent symbols in the painting, virtually all interpretations of the paintings fall into one of two classes. The first class views the painting as representing (and ridiculing) an actual practice, whereby itinerant medical charlatans deceived people into believing that they could cure mental and “psychosomatic” symptoms by removing stones from the head (Bango Torviso and Marias, 1982; Fry, 1946–7; Grabman, 1975; de Groot and de Moulin, 1974; Klein, 1963; Meige, 1932; Menden, 1969). Supposedly, the quack would make a scalp incision and then pretend to remove stones from the head. The second class of interpretation claims that there is no evidence at all for any such contemporary pseudo-medical practice (Gibson, 1973; Bax, 1979; Schubach, 1978). Rather, the painting is viewed as an allegory of the extreme stupidity and gullibility of humans, a recurrent theme in Bosch.

After Bosch, there were a number of works, again usually Flemish, depicting the removal of stones from the head as a cure for madness and folly by Peter Brueghel (Fig. 5), Jan Steen, Pieter Huys, Nicolaes Weydmans, Johannes Theodoor de Bry, and others. Following the two overall interpretations of the Bosch mentioned above, these later works have been interpreted either as depicting an actual common practice of medical quackery (Grabman, 1975; Menden, 1969) or simply as imitating Bosch's allegory of human stupidity (as each of these artists was clearly influenced by Bosch). In both these art-historical interpretations of the depictions of “stone operations,” the possibility that legitimate surgical operations on the head were actually performed to relieve symptoms, was apparently, quite inconceivable (Gibson, 1973; Menden, 1969).

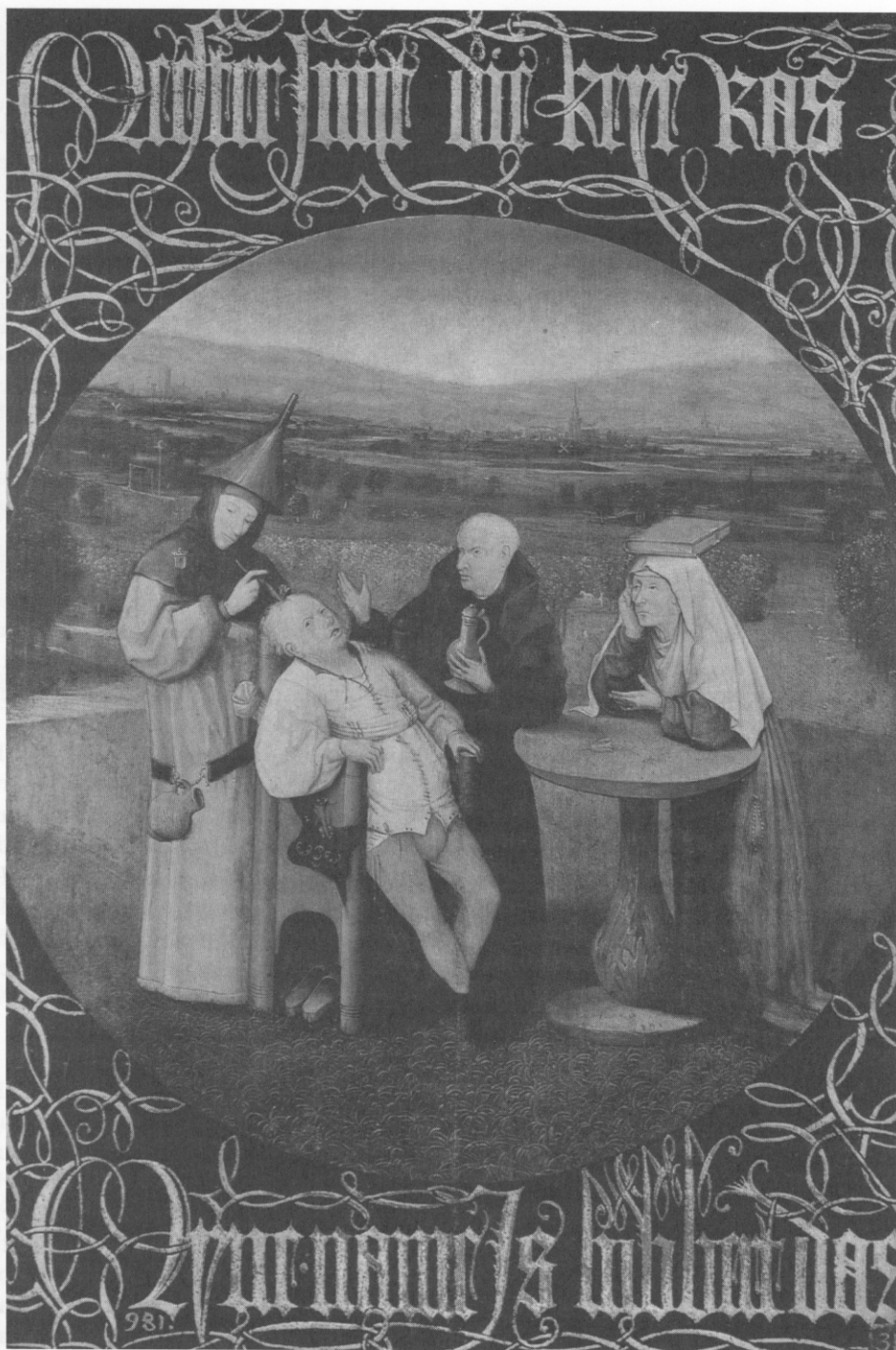


Figure 4. Painting by Hieronymus Bosch, *The Cure of Folly or The Stone Operation* (Prado, Madrid). The inscription in translated in the text (courtesy of Princeton University Library).







Trepanation was a standard surgical procedure during the periods in which the various depictions of "stone operations" were made, such as those in Figures 4 and 5. Furthermore, the procedure was used to treat behavioral disorders as well as head injuries. Thus, it seems likely that Bosch, and the other artists who produced the various pictures of stone operations, knew of the existence of the actual contemporary medical procedure of trepanning. Indeed, the details of their portrayal of the "stone operations" were often very close to the detailed instructional diagrams on trepanning found in surgical handbooks such as Joannis Scultetus, *Armamentarium Chirurgicum* (Scultetus, 1655) (see Fig. 6).

Thus, whatever the abstruse symbolism in Bosch's *Cure of Folly*, whether he was ridiculing the church, the medical profession, trepanning or all humanity; or whether it advocates some religious cult, some wild sexual practice, the advantages of trepanning or nothing at all (Gardner, 1975; Cinotti, 1969; Gibson, 1973; Snyder, 1973; Harris, 1995; Delevoy, 1990; Bango Torviso and Marias, 1982; Bax, 1979; Schupbach, 1978), it seems indisputable that the writing of art historians on this and similar works contain a great deal of folly. Apparently, unknown to many these historians, Bosch's painting and derivatives by Bruegel and others, were based on a very real medical practice of their time. Remarkably, art historians have written reams on the symbolic interpretation of these paintings, but appear to remain unaware that they represented, perhaps among other things, a common medical practice of the time.

By the eighteenth century, "most reputable and enlightened surgeons gave up the practice of... [trephination]...for psychiatric aberrations or headache without evidence of trauma. Thus...the skull was never to be trephined for 'internal disorders of the head.'" (Mettler and Mettler, 1945, p. 34).

## Trepanning Today in Africa

A second source of information on the motivations for trepanation is contemporary traditional practitioners and their patients. There are literally hundreds of twentieth-century accounts of trepanation, particularly in Oceanic and African cultures (Margetts, 1967). Especially detailed and recent ones concern the Kissii of South Nyanza in Kenya and include photographs of the surgical instruments, practitioners and patients, X-rays of the skulls of surviving patients, detailed interviews, and even a documentary film (Margetts, 1967; Grounds, 1958; Coxton, 1962).

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Figure 5. Print by Pieter Breughel the Elder, *The Witches of Mallegem*, Yale Medical Library (Courtesy Princeton University Library). Mallegem was an imaginary village populated by the gullible, "mal" meaning crazy or foolish in Flemish. The witch is shown at the end of the table on the right holding up a stone she had just "extracted." She presumably got the stone from the lock-lipped fellow under the table. A poster on the wall shows stones she has removed and her surgical knife. Other patients with stones in the head are shown around her (Klein, 1963; Grabman, 1975). The seated man with a knife tied to his head may represent a technique to "draw out excess blood or bad humors," a custom that seems to have survived into the twentieth century (Grabman, 1975, p. 385).



Figure 6. Detail of figure from a seventeenth-century surgical handbook showing the start of a trepanation (Scultetus, 1655).

Trepanning among the Kissii is carried out primarily for the relief of headache after some kind of head injury. It is apparently not done for “psychosis, epilepsy, dizziness or spirit possession.” (Margetts, 1967, p. 683). The operation is carried out by general practitioners of medicine and takes a few hours. Restraint rather than anesthesia is used. The hole in the skull is usually made by scraping with a sharp knife with a curved tip to avoid injuring the dura. Various medicines are administered before, during and after surgery but their nature does not seem to have been studied. Mortality is described as low. The practitioners and patients seem to be quite satisfied with the results of the operation (Margetts, 1967; Grounds, 1958; Coxton, 1962).

Although headache after head injury is the most prevalent reason given for trepanning by contemporary practitioners of traditional medicine in Kenya and elsewhere, other reasons are cited in the literature such as “evil spirits..vapors, humors, pressures and imagined foreign bodies in side the head.” (Margetts, 1967, p. 692). Furthermore, the headache itself may be attributed to one or more of these causes, instead of, or in addition to a head injury.

## Trepanning on The Internet

Today, the practice of trepanning is not confined to surgical suites or traditional medicine men. It is advocated by the International Trepanation Advocacy Group as a means of enlightenment and enhanced consciousness. Their general idea is that when the skull sutures close in childhood it "inhibits brain pulsations causing a loss of dreams, imagination and intense perceptions and more areas of the brain functioning simultaneously" and "increases originality, creativity and ...testosterone level." Beyond such "physiological" arguments, the group supports the practice by pointing out its ancient, widespread and continuing presence in other cultures. The Group maintains a sophisticated web site, <http://www.trepan.com>, with links to first person and journalistic accounts of trepanning, reproduction of old drawings of trepanation in Europe, a chat room, several historical papers, and even a paper by Sokoloff on brain metabolism. This particular form of alternative medicine recently gained considerable if not entirely positive publicity: in November 1998 it was featured on "ER", the television soap opera set in an emergency ward.

Much of the defense for alternative medicine treatments is that they must work because they have been around for such a long time, an apparently attractive argument for the increasing popularity of 5000+ year-old Chinese traditional medical practices. However, the case of trepanning suggests that just because a procedure is very old does not mean it is necessarily an effective one, at least for enhanced enlightenment and creativity. Trepanning a small hole, they say, restores the intracranial pulse pressure which leads to a permanent increase of the brain-blood volume which leads to accelerated brain metabolism.

## Conclusion

The commonest view of the prehistoric and the non-Western practice of trepanning, especially in the absence of a depressed fracture, was that it represented some kind of "superstition," "primitive thinking," "magic" or "exorcism." Yet an examination of the reason for the practice among the Hippocratic and early European doctors as well as among contemporary Kenyan practitioners suggests a different view. Trepanning may have appeared, in these contexts and cultures, to have been an effective empirical approach to head injury and the headaches that often accompany them. Headaches after head injury often do feel like "a pounding" and "pressure" inside the head, and thus the idea that a hole in the skull would relieve them is not necessarily "magical" or "bizarre." Furthermore, epidural bleeding does sometimes accompany head injury, and in these cases trepanning might have actually reduced intracranial pressure. Finally, the apparently excellent survival rate meant that the procedure, at least until it moved into a hospital setting, may have met the prime requirement of medicine, to "do no harm."

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