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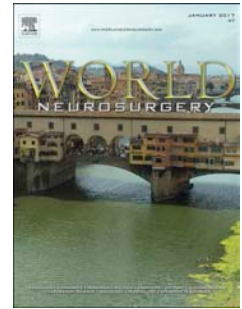
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**Trepanation to treat a head wound:
a case of neurosurgery from 13th century Tuscany**

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Abstract

During the archaeological excavations conducted in the 13th century cemetery of the Church of S. Agostino in Poggibonsi, Tuscany (Italy), a skull with evidences of neurosurgical intervention was brought to light. The skull, belonging to an adult male, shows two traumatic lesions produced by bladed instruments.

The first lesion, located on the anterior part of the parietal bones, involved only the outer cranial table; bone remodeling indicates that the individual survived the injury for a long time. The second lesion, located on the frontal bone, involved all the thickness of the bone; the absence of reparative processes allows a diagnosis of *peri mortem* lesion. In order to treat this wound the patient was submitted to a surgical intervention. In fact, in correspondence to the lesion, an oval bone loss, with clean and well-defined cutting-edges, can be interpreted as the result of a trepanation, probably performed to clean the wound and to remove any bone splinters. Half of the bone “rondella” was found *in situ*; it can be hypothesized that the surgeon decided to replace the bony piece to protect the brain. However, the surgical intervention failed and the patient died soon afterwards. Trepanation for the treatment of cranial traumas is described by several medical classical and medieval Authors, whose texts were available in the 13th century. This case represents a rare Middle Ages evidence of neurosurgery practised to treat a bone injury.

Introduction

Trepanation is probably the most ancient form of craniotomy practised on living people and is defined as “the production of a defect in the skull vault to create communication between the cranial cavity and the environment”.¹

Trepanation has been performed since prehistoric times; the first case was found by Bernard de Montfaucon in Cocherel (France) in 1685, but its medical significance was not recognized at that time. Later, attention began to be paid to the practice of trepanation thanks to the work of Paul Broca, who was the first to recognise the signs of this surgical procedure on a Peruvian skull

discovered in 1865.² Since then, a number of cases have been brought to light from all continents and from all times.³

Across time and space, trepanation has been performed by using three main techniques. The most ancient of these is scraping, which consists in a repeated forward and backward movement on the outer cranial table by means of a sharp instrument, until complete perforation has been obtained. Sawing is performed by incising the bone with a sharp tool, which produces perforations of various shapes and sizes. Drilling uses a pointed stone or metallic tool to exert pressure and to repeatedly draw and redraw a groove, until a troncoconical hole with a circular outline has been obtained.⁴

The reasons for trepanation among different peoples and cultures can be grouped into two main categories. Magico-therapeutic or ritual purposes were pursued to treat disturbances such as headaches, epilepsy and mental disorders, attributed to the presence of supernatural forces, or to cast out evil spirits and demons, allowing them to escape through the hole that had been cut in the skull.⁵ It can be hypothesized that trepanation was used for therapeutic reasons in the presence of cranial traumas, for which it was necessary to reduce the intracranial pressure and to remove bone splinters, which were dangerous for the underlying structures. A number of paleopathological studies have demonstrated an association between trepanation and traumatic lesions.⁶

The aim of this paper is to report on a rare Italian Medieval case of trepanation for the treatment of a head wound.

Materials and Methods

During the archaeological excavations conducted in 2007 in the Medieval cemetery of the Church of S. Agostino in Poggibonsi, Tuscany (Italy), a collective tomb was investigated. The large funerary structure dating back to the 13th century contained the skeletal remains of 24 individuals, among which a skull with evidences of cranial injuries and surgical intervention was found. Sex and age of the human skeletal remains was assessed by using classical anthropological methods.⁷ The

distinction between *ante mortem*, *peri mortem* and *post mortem* injuries and the identification and description of cranial wounds, including the type of weapon used to produce them, the direction of the blow, and the position of the aggressor, is based on the criteria defined in the literature.^{8,9,10}

The macroscopic observation of the bones was followed by imaging study. A direct radiology digital equipment (FCR Velocity by Fujifilm) was used for conventional X-rays, with the following parameters: 10-12 mAs with 54-60 keV, DFF 110 cm.

Results

The partially incomplete skull, impossible to associate with other bone elements, since the skeletons in the multiple tomb were commingled and not in anatomical connection, belongs to a mature male aged between 45 and 55 years.

The specimen exhibits two traumatic lesions. The former, located on the anterior part of the parietal bones, 2.1 cm distant from the bregma and parallel to the coronal suture, consists in a linear wound measuring 4.3 cm and involving only the outer cranial table. The injury shows signs of healing, since the margins are completely remodeled (Figure 1A and B). This sharp force trauma involved the cranial vault perpendicularly and this topographic position suggests that the victim was probably in a lower position with respect to the aggressor.

The second lesion is located on the right portion of the frontal squama and involves all the thickness of the bone, which has clean and well-defined edges. The wound is compatible with a sharp force lesion, delivered by a left-handed aggressor standing in front of the victim, and shows no signs of healing. Only the superior and inferior extremities (with triangular section) of this injury can be recognized; in fact, the central portion of the wound is obliterated by an oval 3x2 cm bone loss, characterized by clean cutting-edges along the outer cranial table, whereas the margins of the inner cranial table are irregular (Figure 2A). The absence of bone remodeling is confirmed at X-ray (Figure 2B).

Finally, a semilunar bone fragment, measuring 3.6x1 cm and perfectly fitting in the left half of the oval defect, was recovered. The medial margin of the bony “rondella” is straight and irregular, while the lateral margin is convex and well-defined (Figure 2A). The right portion of the “rondella” was not found.

Discussion

The two traumas in the Poggibonsi skull were sharp force lesions caused by bladed weapons such as swords or axes, typically used during the Middle Ages.

The first episode of interpersonal aggression was inflicted by a sharp and narrow blade, probably a sword, as suggested by the linear aspect of the lesion; the clean well-defined edges and flat and smooth cut surfaces, typical of sharp force lesions, are obliterated by the healing process. In fact, the superficial trauma is clearly *ante mortem*, as indicated by the signs of healing, and the individual long survived to the injury.

After the first episode, the subject underwent a second frontal lesion, which involved the entire thickness of the frontal bone and whose triangular section referred to a thicker blade, presumably a larger sword or axe. The biomechanical dynamics and damaging effects of this type of injury are related not only to the action of the cut, but also to the blunt force of the instrument, which may have involved vital structures like the meningeal membranes and the brain.¹¹ In fact, this second aggression was fatal, as demonstrated by the absence of reparative signs in the form of periosteal reaction along the margins and the diploë; therefore, this lesion can be classified as *peri mortem*, being lethal either immediately or a few days after the injury.

The oval bone loss in the centre of the second lesion can be interpreted as the result of a surgical treatment for head injury, whose “scenario” can be described as follows. The surgeon incised the skin to reach the bone with a cutting instrument, in order to explore the nature of the lesion. He decided to treat the fracture with trepanation by using the technique of incision, which involved only the outer cranial table. Tools with curved blades, such as chisels, are likely to have been used

to incise the outer table; then, a lever was probably applied to break all the thickness of the bone. In fact, the incision margins of the outer cranial table are well defined, while those of the inner cranial table are irregular. This procedure was safer, since it avoided the risk of damaging the meninges. Finally, the surgeon smoothed the fracture margins from any bone spurs and spiculae by means of raspatories. The aim of the surgical intervention was to clean the wound and remove possible bone splinters.

As concerns the presence of the bony “rondella” corresponding to the left half of the oval defect, the surgeon is likely to have replaced the bony “rondella” *in situ* to protect the brain, but the patient survived briefly after the intervention. With regard to the other half of the “rondella”, the surgeon may simply have decided to get rid of the bony piece after incision, as it was probably fragmented.

Trepanation performed to treat cranial traumas was described in detail by several classical and Medieval medical authors, including Hippocrates,¹² Galen,¹³ Paul of Aegina¹⁴ and Albucasis,¹⁵ whose texts were available in the 13th century. In other surgical treatises contemporary to the examined skull, including the *Chirurgia* of Constantine the African,¹⁶ the *Practica Chirurgica* of Roger Frugard (book I, chapter 1-17), the *Chirurgia* of Roland of Parma (book I, chapter 1-13), the *Chirurgia* of Teodorico de Borgognoni (book II, chapter 2-6) and the *Chirurgia Magna* of Bruno of Longoburgo (chapter XVII), the descriptions to manage head wounds are less detailed if compared with the original passages of Galen, Paul of Aegina and Albucasis.^{17,18} However, the surgical intervention observed in the Poggibonsi skull seems to have followed the more detailed recommended procedure.

Here, we report on the intervention described by Albucasis in the thirtieth book of his work *Al Tasrif* dedicated to surgery, which describes the main surgical procedures known at that time, accompanied by precious illustrations of the instruments used. This book was translated into Latin by Gerard of Cremona in the 12th century, and was to remain the primary source for medical knowledge on surgery during the Middle Ages. Albucasis closely follows the classical authorities

in several passages, as in the chapter reserved to the treatment of head fractures (book 3, chapter 2), which appears similar to that of both Galen and Paul of Aegina.

Albucasis explains that, if the fracture has already reached the meninges with fragmentation of the bone and depression, the surgeons should shave the head and lay the bone bare; he continues: *“then begin the trepanning and removal of the bone. This may be done in one of two ways. One way is to cut the bone with a fine-bladed chisel, then another chisel a little broader and use another chisel still broader than the second”. You should have by you a number of different chisels, some broader than others, and some shorter than others; their tips should be exquisitely sharp*. The specific type of chisel used to incise the bone is known in Galen¹⁹ and Paul of Aegina²⁰ with the name *cycliscus*, which means “hollow chisel”, variable in size and resembling a gouge still in use in modern neurosurgery (Figure 3). For those parts of the head in which the bone is strong and thick, such as the frontal and the occipital portion, Albucasis suggests the use of drills to obtain perforations. In the skull of Poggibonsi the fracture is on the frontal portion, where the bone is thicker and, in fact, the local surgeon used a chisel and not a drill. In any case, Albucasis recommends to *“observe the outmost caution that neither the drill nor chisel touch any part of the membrane”*. After incision or drilling *“you will have to scrape away and smooth out all the roughness in the remaining bone with another instrument, resembling a chisel, except that it must be finer and slenderer than any of them”*.

The other way of operating is based on the use of a particular instrument, the lenticular knife. This instrument was made of a lenticular end, smooth and not sharp, which had to be placed on the meninges, in order to protect them, and of a sharp blade, which was to be placed on the bone in order to cut it. Albucasis clarifies: *“Then with a small hammer strike the tool on one side until you gently cut through the bone in a circle”*.

Of these two methods, one based on the use of chisels and the other based on the use of a lenticular knife, the surgeon of Poggibonsi adopted the former, as demonstrated by the features of the oval bone loss; as a matter of fact, if the lenticular knife had been used, the incision should

have involved all the thickness of the bone. On the contrary, the cut is visible only on the outer table, since the chisel was carefully applied on the bone surface to preserve the meninges; once the external cranial table had been cut, the bone portion was probably detached by applying force with a lever, as demonstrated by the irregular margins of the inner table.

This case study is relevant considering that trepanations dated back to the Late Medieval Ages are uncommon in Italy; in fact, only a few cases are reported in literature.^{21,22} However, the surgical operation was widely used in that period, as several cases from other European countries demonstrated.^{23,24,25,26,27} The diffusion of this practice is also reflected in the myth of the stone of madness, attested during the Middle Ages. According to this myth, a stone placed into the head would have been considered responsible for the person's folly. The stone had to be found and eliminated through trepanation, as depicted in the famous painting of Hieronymus Bosch of 1494. The reposition of the "rondella" is rarely attested; from the Italian territory only a case from Trasano, dating back to the Neolithic, a case from Sisaia-Dorgali dated back to the Bronze Age, and an evidence from Pontecagnano (PC 990), dating back to the 5-4th centuries BC, are documented⁴; however, in all these cases the replacement of the bone disc was followed by resorption of the "rondella", indicating a long-term survival.

Furthermore, the surgical procedure observed in the skull of Poggibonsi demonstrates that the local surgeon probably had access to the medical literature of that period and therefore that he was skilled in the management of head wounds. Poggibonsi was a large village 30 km far from the city of Siena, where the surgeon is likely to have attended medical studies. Indeed, the birth of the University of Siena, which also included a school of medicine, dates back to 1240.²⁸ It can be reasonably hypothesized that this surgeon had access to the medical literature of the period and that he probably followed the prescriptions of surgical texts, like the one of Albucasis, which was one of the most famous during the Middle Ages. The features of the lesion observed in the skull of Poggibonsi reflect the procedure of trepanation recommended in cases of fractures of the head, from Hippocrates onwards. Unfortunately, the patient died during surgery or soon after the

intervention. It is impossible to establish whether the death was due to the inexperience of the surgeon or to the severity of the sword injury; however, the trauma must have been severe, as it was penetrating and had probably reached the meninges, thus resulting in a fatal outcome.

Conclusion

This case, observed in an adult male skull excavated from the collective tomb of a 13th century cemetery in Tuscany, represents a rare direct Medieval case of neurosurgery practised to treat a head wound. The individual suffered from a lesion produced by a bladed instrument and was submitted to trepanation by using the incision technique. The intervention was probably aimed at cleaning the wound, and removing the bone splinters; the replacement of the “bone rondella” was likely made in order to protect the brain. Despite the good medical knowledge of the surgeon, who closely followed the surgical procedure prescribed by the medical authorities, the patient died in surgery or soon after, probably for the severity of the trauma.

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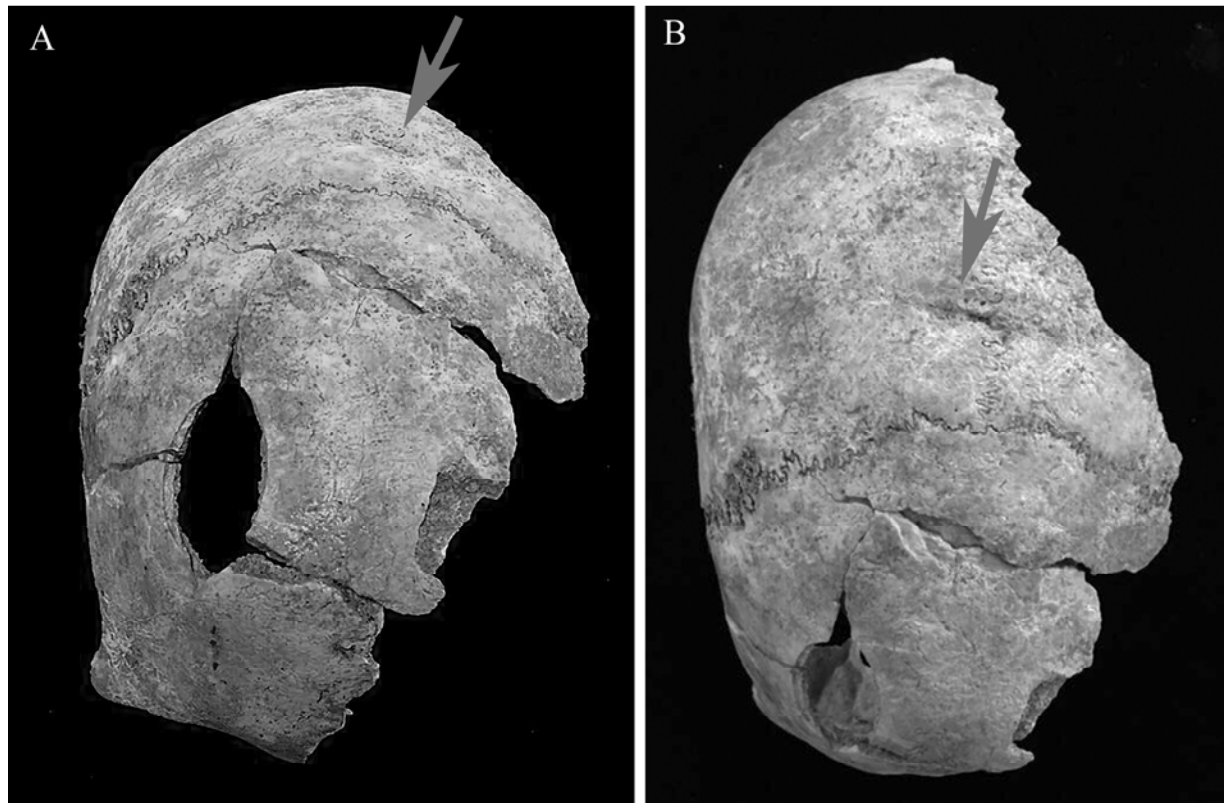
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Figure Legend

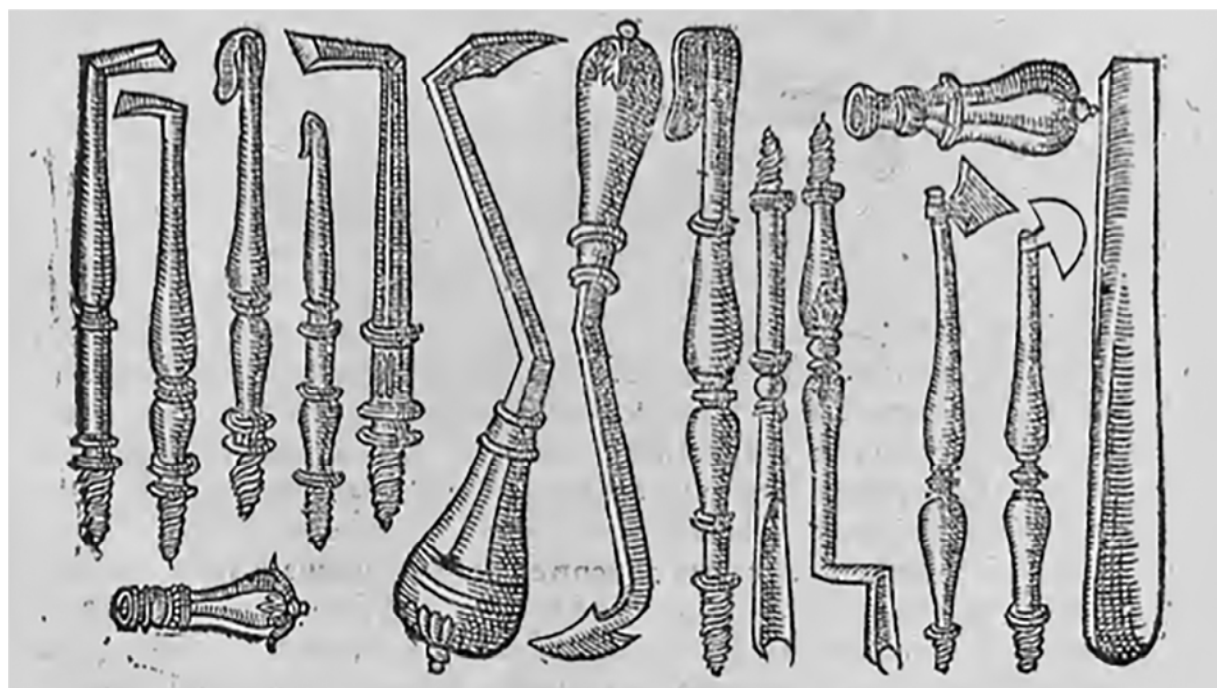
Figure 1 Skull from Poggibonsi: superficial sharp-force injury (arrow) and penetrating sharp force injury located on the right portion of the frontal bone (A); detail of the lesion on parietal bones showing reparation (arrow) (B)

Figure 2 Detail of the trepanation with replacement of the bone “rondella” (A); detail of the X-ray of the frontal lesion with upper and lower triangular extremities and central oval bone loss (B)

Figure 3 Surgical instruments with different types of chisels for trepanation by the incision technique: the first, as well as the fourth and fifth, from the right side are *cyclisci* (from Gauliaco G. *Chirurgia Magna*. Lugduni: apud Simphorianum Beraud et Stephanum Michaëlem; 1585;59).²⁹ Drawings from Albucasis are too schematic to appreciate the shape of the surgical tools







Abbreviations List

No abbreviations or acronyms are used into the manuscript.