Reconstruction of Skull Defects in the Middle Ages and Renaissance

The Neuroscientist
1–7

DOI: 10.1177/1073858414559252
nro.sagepub.com
SAGE

Paolo Missori[1], Antonio Currà[2], Harry S. Paris[3], Simone Peschillo[1], Francesco Fattapposta[1], Sergio Paolini[4], and Maurizio Domenicucci[1]

Abstract

In Egyptian, Greco-Roman, and Arabic medicine, the closure of a skull defect was not provided at the end of a therapeutic trepanation or in cases of bone removal. The literature from the Middle Ages and Renaissance disclosed some striking and forgotten practices. Gilbertus Anglicus (c. 1180 to c. 1250) cites the use of a piece of a cup made from wooden bowl (ciphum or mazer) or a gold sheet to cover the gap and protect the brain in these patients; this citation probably reflected a widely known folk practice. Pietro d'Argellata introduced the use of a fixed piece of dried gourd for brain protection to reconstruct a skull defect. In the late Renaissance, the negative folklore describing this outlandish practice likely led to the use of silver and lead sheets. Nevertheless, for centuries, large numbers of surgeons preferred to leave the dura mater uncovered after bone removal, and failed to apply any brain protection.

Keywords

bone, brain, cranioplasty, protection, skull, trepanation

Introduction

The brain is a unique organ that nature has enclosed within a hard shell. A skull defect due to bone loss after an injury increases the risks of pathological and traumatic events and causes aesthetic disfigurement. For these reasons, reconstruction of the skull bone defect, or cranioplasty, has been considered a mandatory procedure in every culture and time. The first surgical procedures on the brain included trepanation of the skull. Some documents also described extremely rare cases of ancient reconstructive surgery for a skull bone defect (Verano and Andrushko 2010). Indeed, in Egyptian, Greco-Roman, and Arabic medicine, the closure of a skull defect was not provided at the end of a therapeutic trepanation or in cases of bone removal. Instead, care was based on gauzes and cot sheets soaked with medical ointments and powders. These were repeatedly placed on bone and dura mater to provide wound healing. Ibn Zuhr (1092-1162), an Andalusian Muslim physician, in the treatment of head injuries with bone fractures, advised only to remove the broken bone, and place honey, palm, or rose ointment in the wound, declaring, ". . . *non vidimus neque audivimus chirologum aliquem in hoc nostro tempore qui fit perfectus in hac arte quia si aliquis esset perfectus: nemo ex fractura cranei solius moreretur*." This translates to: "In our time, we have not seen or heard of any surgeon who is considered an expert in this technique, because if there was someone experienced, no one would die of a fracture of the skull alone" (Ibn Zuhr 1497). However, texts from the Middle Ages and Renaissance have revealed that, surprisingly, some famous physicians who dealt with skull trepanation and fractures also suggested a reconstructive procedure for therapeutic purposes. For a long time, those reconstructive procedures were not widely shared among physicians who treated head fractures or performed trepanations of the skull. Thus, most physicians continued to perform wound closures according to the old teachings of Hippocrates, Galen, and Celsus. The history of the first efforts to protect the brain with various devices is described here to recount the slow progress in the concept of cerebral protection in European medicine.

[1]Department of Neurology and Psychiatry, Neurosurgery, "Sapienza" University of Rome, Rome, Italy
[2]Department of Medical-Surgical Sciences and Biotechnologies, Neurology Unit, Ospedale "A. Fiorini" Terracina, LT, "Sapienza" University of Rome, Polo Pontino, Rome, Italy
[3]Department of Vegetable Crops & Plant Genetics, Agricultural Research Organization, Newe Ya'ar Research Center, Ramat Yishay, Israel
[4]Department of Medical-Surgical Sciences and Biotechnologies, Neurosurgery, IRCCS "Neuromed", Pozzilli, Italy

Corresponding Author:
Paolo Missori, Neurochirurgia, Viale del Policlinico, 155, 00161 Rome, Italy.
Email: missorp@yahoo.com

In writing this article, we reviewed original manuscripts and early books available from the ancient period (5th century BC to AD 800), the Middle Ages (AD 801-1400), the Renaissance (1401-1600), and between the Renaissance and Enlightenment periods (1601-1751). For this study, we included articles that described the trepanation procedure or a cure for skull fracture from all physicians that dealt with these therapies.

Origins: Wood or Gold

Hippocrates (5th century BC), Celsus (c. 14 BC to c. AD 37), and Galen (AD 129-216) are considered the fathers of modern medical and surgical therapy. However, in performing a skull trepanation, they did not close the skull gap; instead, it was treated with gauze dressings soaked in medical ointments and cot sheets placed on top of the dura mater (Celsus 1478; Galeni 1537; Hippocratis 1525). This was the official cure, performed for centuries in the ancient period and the Middle Ages by a long list of Greco-Roman and Arabic physicians, without any variation, other than the substances employed. At the Schola Medica Salernitana, head fractures were cured by first removing scraps and pieces of broken bone, and then placing on the dura mater gauzes and cot sheets soaked with medical ointments and powders (Daremberg 1854). The wound had to become flesh and no single reconstructive procedure was planned. Unexpectedly, in the Middle Ages, Gilbertus Anglicus (c. 1180 to c. 1250) described the treatment for a skull fracture in a short sentence: "*quidam solent imponere et cessante sanguine loco cranei extracti peciam ciphi de mazer aut laminam auri solent imponere quae hodie dimittitur*," which translates to: "Some customarily apply, after the blood has stopped, over the place where the skull was removed, a piece of a cup made from wooden bowl or sometimes a plate of gold, which is now abandoned" (Figs. 1 and 2) (Gilbertus 13th century). In that time, the *ciphum* was a very common utensil (made from a maple tree) for drinking or for preparing and serving food (Fig. 1). This same procedure was described by Henri de Mondeville (1260-1320), with his explanation for why it was advisable: "*Notandum, quod aliqui consueverunt ponere supra cranium, postquam ejus vulnus erat tentis repletum, aliquid frustrum ciphi alicujus et hoc propter duas causas et bene sicut mihi videtur: 1a causa, ne motus cerebri expellat tentas a vulnere cranei; 2a, ne compressio ex ligatura facta comprimeret nimis tentas et laederet duram matrem* . . .," which translates to: "It must be noted that, since the opening was filled with gauzes, some used to apply on the skull a piece of wooden cup, which seems to be fine to me, for these two reasons: first, so that the movement of the brain does not push out the bandages from the opening of the skull; and second, so that the pressure from the bandage does not overly tighten the gauzes and harm the dura

Figure 1. In an ancient manuscript (Cod. Bodmer 147, Estoire Del Graal, Fondation Martin Bodmer, page 10v, end 13th century), this image is shown of the Gospel scene, where Mary Magdalene is washing the feet of Jesus; two *ciphi de mazer* are shown, at both ends of the table, represented as simple wooden bowls. The drinking tool was worked up to a thin layer of wood to make it lightweight.

mater" (Henrici de Amondavilla 1306). The rest of the report provided further information that the piece of the wooden cup is only temporarily placed over the wound: ". . . *rurales aliqui assistentes in appositione ciphi non revertentes in sequenti praeparatione crediderunt, quod dictum frustrum ciphi in perpetuum remaneret inter vulnus*," which translates to: ". . . some rural witnesses of the positioning of the cup, who did not return to witness the next change of wound dressing, believed that the piece of cup must remain forever in the wound." Likewise, Guy de Chauliac (c. 1300 to c. 1368) reported on the treatment for a fracture of the skull: "*Antiqui tamen ponebant petiam unius ciphi et erat truffa quia assistentes qui non erant in secunda remutatione credebant quod ibidem loco ossis deperditi remaneret et desuper in vulnere carnis ponantur alii lichinj sicci . . . et in ista operatione satis laudo Henricum*," which translates to: "The ancients, however, placed a piece of wooden cup (over the wound); this was a deception to some of those who attended because, when they were not present at the change of wound dressing, they believed that (the piece of wooden cup) remained to replace the lost bone; then, other dry bandages were placed over the wound … in this procedure, I praise Henricum (de Mondeville)" (Guidone de Cauliaco 1363).

The Gourd

The favourable effects of performing this type of treatment were communicated across Europe and even to

Figure 2. The cathedral church of Lincoln, Lincolnshire (United Kingdom) is one of the high points of medieval architecture in England. In the Middle Ages, the minster ranked as the third greatest pilgrimage center in England. On the east gable of the cathedral, over two gothic windows, still visible today there are two sculptures (13th century) resembling pilgrims. The right pilgrim in the left hand "holds a bowl of the usual form of the *mazer* . . ." (from an old drawing: Trollope 1853).

Italy. Pietro d'Argellata (– to c. 1423) described the application of a different protective material on the skull after performing a trepanation of the skull: "*Aliqui tunc timentes de compressione pannorum apponunt post positione medicine, cucurbitam siccam confirmat eam ex omni latere super os et ipsam prohibet percussionem vel compressionem panniculorum*," which translates to: "Some, who fear squeezing the brain membranes, after applying the medicinal ointments, will place a piece of dried gourd over the wound, fix it over the bone on each side, and this prevents injury and compression of brain membranes" (Fig. 3) (de Lacerlata 1480). The value of this expedient was also declared by Leonardo Bertapaglia (c. 1380-1463), who gave more details on head fractures that required bone removal: ". . . *huic infirmo supra foramen cranei prius posito unguento apposui unam petiam cucurbite.i.zuche in pluribus locis perforate*," which translates to: ". . . to this patient, over the opening in the skull, and before applying the ointment, I placed a piece of cucurbita namely a gourd, with holes punched in several places" (Bertapalie 1498). He explained, as did Henri de Mondeville, the clinical reasons for brain protection, but he added one more explanation: "*cucurbita ponitur in magnis fracturis capitis quia est corpus leve et sine aliqua mala compressione et prohibet ne aer extrinsecus cerebrum alteret*," which translates to: "the gourd is placed over the openings of large head fractures, because it is a light object that does not cause major squeezing, and it also ensures that the external air will not trouble the brain." Berengario da Carpi (1460-1530) expressed a favorable opinion on the application of this type of protection for the dura mater:

Figure 3. The early printed and painted representation of the *cucurbita* (*Lagenaria siceraria*) in an incunabula before the discovery of the Americas (Cuba 1485). It depicts the bottle shape of the fruit. Before the printed image, in Medieval manuscripts, the bottle gourd was beautifully and carefully represented in drawings (Paris and others 2009).

> There are some who, in place of the removed bone, over the skull, lay a piece of dried gourd above the aforementioned shroud, to prevent the bandages from pressing on the dura mater; this modality I cannot reproach nor praise. Sometimes

> I placed (this type of protection), but I also treated many without that successfully. Only in one case could I praise the application of this gourd: when a large part of the skull is removed, and there is danger that the gauzes and bandages might squeeze the dura mater. Then, I believe it a very useful practice, because it prevents the development of disease due to pressure from the bandages . . . (Berengario 1535).

The same opinion was professed by Andrés Alcázar (c. 1490 to c. 1585) and Pietro Martire Trono (– to c. 1584). To protect the dura mater and avoid pressure from the bandages, the former declared that it was worthwhile to apply: ". . . *cucurbitulae frustum multis, crebrisque foraminibus* . . .," which translates to: "a piece of gourd with several holes" (Alcazaris 1575); and the latter explained, "*ne dura mater comprimatur . . . apponere frustrum cucurbite scice*" translating to "so that the dura mater is not compressed . . . apply a piece of dried gourd" (Troni 1584). They also mentioned the unpleasant behaviour of Henri de Mondeville, described by some individuals that were present only at the first wound dressing, who claimed, "*vicatim ac ianuatim testantur cucurbitae frustrum intra vulnus aglutinatum fuisse: ridiculum sane, atque cachino dignissimum*," which translates to: "from village to village and door to door, people testified that a piece of gourd was glued into the wound, which is, without a doubt, ridiculous and worthy of laughter" (Alcazaris 1575).

Silver or Lead

For these reasons, in the late Renaissance, the placement of a gourd in the wound for brain protection, either temporarily or long term, appeared to be replaced with the placement of a more expensive material. The "*laminam auri*," or gold sheet, was introduced by Gilbertus Anglicus, and others applied a low-cost silver or lead sheet over the dura mater. This practice was clearly described by Gabriele Falloppio (c. 1523 to 1562), who mentioned the "*lamina aurea*," and by Giovanni Andrea Della Croce (1509 - 1575) (A Cruce 1573; Falloppius 1566), who mentioned three alternatives: ". . . *antiqui laminam tenuem argenteam, aut auream ubique perforatam, aut siccae cucurbitae . . . superponere ausi erant, ne pariter membrana ab extrinsecis comprimeretur; et hinc vulgares pro ablato osse cucurbitam applicari affirmant* . . .," which translates to: ". . . the ancients used to apply a thin sheet of silver or gold with numerous holes, or a dried gourd, to ensure the dura mater was not compressed by external pressure, which is why the common people say that a gourd is applied when the bone is removed . . ." (A Cruce 1573). Ambroise Paré (1510-1590) also described treatment for head wounds with large bone loss, but he complained of a very disgraceful behaviour:

> In truth, in this situation, it is the pleasure of some crooks, who boast of the false title of surgeon, to hide a scam. When these are called to heal wounds in the head, in which there is loss of bone, they convince the sick and those who care that the place where the bone was lost must be covered with gold leaf. Therefore, they manufacture this in front of the patient, and even explain how it can be made into a convenient form for application; but then, they variously turn, apply a little, but then hide in their purse; with this trick, they betray the deceived. Others are pleased to conclude their work by covering the gap due to missing bone with the dry bark of a gourd, which is wrapped like a whip; in this way, they deceive the ignorant. (Paré 1582)

In the post-Renaissance period, many other physicians and surgeons continued to describe the application of protective coverings over the dura mater or brain.

The last individual to report the application of a piece of dried gourd with several small holes was Carlo Musitano (1635-1714) (Musitani 1698). The gold sheet continued to be used, but silver and lead sheets were progressively introduced, probably to make the cost more affordable, by Ludovico Settala (1552-1633), Cesare Magati (Liberato da Scandiano: 1579-1647), Louis Queyrats (16- - to -16- -), Antonius Nuck van Leiden (1650-1692), Herman Boerhaave (1668-1738), Gerard van Swieten (1700 - 1772), and Franz Joseph Grienwald (1708-1743) (Boerhaave 1728; Grienwaldt 1732; Magati 1616; Nuck 1696; Queyrats 1657; Septalii 1630; van Swieten 1744). Luca Tozzi (1638-1717) did not specify the material of the sheet used to cover the dura mater and brain: ". . . *Si vero membrana detecta appareat, tunc solent Chirurgi laminam pluribus foraminulis pertusam, ad illius custodiam, et puris repurgationem, superponere, et meninges, ac cerebrum contegere*," which translates to: ". . . Indeed if the dura mater is discovered, then surgeons are usual to place a sheet punched with several small holes, to protect that, to clean from rotten, and cover the meninges and the brain." He did specify that ". . . *haec peritiam potius experti Chirurgi, quam theoriam expostulant*," which translates to: ". . . experienced surgeons claim to prefer this method in practice, rather than in theory" (Tozzi 1710) (Fig. 4). The last innovation was introduced by Augustin Belloste (1654-1730), who, after trephining the skull, covered the dura mater with a lead sheet that possessed two "wings" for fastening the sheet to the lateral edges of the skull (Fig. 5) (Belloste 1696). He described this design:

> Je laisse à cette même plaque deux petites colonnes aux deux côtés sans inégalitez, dont je ploye l'extremité de chacune pour former une anse de chaque côté qui vienne s'appuyer sur les bords du crane pour la soûtenir et l'affermir, observant que lesdites colonnes égalent en longueur l'épaisseur du crane . . .

Figure 4. In the post-Renaissance period, the majority of surgeons treated fractures of the skull in which there was bone removal or loss, with gauze dressings soaked in medical ointments and cot sheets placed on top of the dura mater (Sculteti 1656). The bandages and tightened gauzes could put pressure on the dura mater.

which translates to

> I leave on the same plate two equal small strips, which project on both sides, the extremity of each strip is bent to form a hook on each side that rests on the edges of the skull to support and strengthen the placement; note that the said strips should be equal in length to the thickness of the skull.

A Perspective

The first written document related to reconstruction of skull defects dates back to the Middle Ages, written by Gilbertus Anglicus. He reported the practice of some unknown physicians, who temporarily placed over the dura mater a piece of *ciphum* or *mazer*. In the cathedral church of Lincoln, Lincolnshire (United Kingdom) a sculpture of a pilgrim (13th century) carries a mazer for begging and to rely on charity (Fig. 2). In the text,

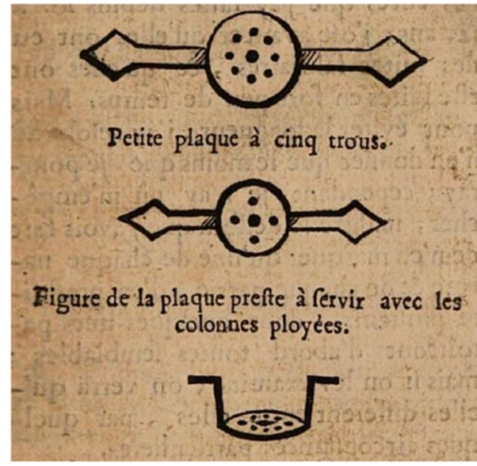

Figure 5. The design for the Belloste sheet (Belloste 1696). It possessed some holes in the center to apply medical substances, according to antique medicine, and two wings on the lateral edges. The wings could be bent to form a hook on each side, and these rested on the edges of the skull for support and strength.

Chirurgia, of the Schola Medica Salernitana, the *ciphum* is mentioned as a wine goblet (Daremberg 1854). It is not clear where the use of a piece of a cup made from wooden bowl to cover the gap and protect the brain originated; it probably derived from a folk practice of English physicians of the Medieval period caring for large skull defects. Gilbertus Anglicus proposed that a plate of gold could be used as an alternative, presumably for patients who had a high income. The reason for performing such an unusual procedure was later masterfully explained by Henri de Mondeville, applied the *ciphum* in the first dressings, and afterward removed it, because the application of a foreign body inside a wound was poorly regarded in the medical culture. Pietro d'Argellata unexpectedly exchanged the piece of bowl with a piece of the cortex of a dry gourd (*cucurbita*); this was fixed as a lasting device, presumably with surgical stitches. It is assumed that the introduction of this different material was due to the easy availability of the gourd in Medieval medicine, and it was very inexpensive compared with a more elaborate *ciphum*. Of note, in the Middle Ages in Europe, the *cucurbita* was *Lagenaria siceraria* (bottle gourd), which was used both as a therapeutic substance and a common utensil in the household (Fig. 3) (Janick and others 2007; Paris and others 2009). Further information from Leonardo Bertapaglia described an evolution in the use of a piece of gourd; the cup was punched in several places to favor penetration, through the cortex, of medical ointments applied by the physician. He also highlighted that the gourd prevented the effects of atmospheric pressure over the brain, which may have been an early intuition of the syndrome of the trephined. Clashing with the opinion of some ignorant individuals, Bertapaglia declared that the gourd did not reabsorb, but remained in the wound. It seems that the application of the gourd to protect the brain was not well accepted in the medical arena; this reluctance was probably related to the sacred image of the human body and to the folklore that it was an outlandish practice to leave the gourd inside the head wound. Obviously, traces of these cerebral protective devices cannot be found currently in necrotic remains, because both the wooden bowl and the gourd materials are easily perishable over time. In the Renaissance, the substitution of the gourd with a gold, silver, or lead sheet placed on the dura mater disrupted the embarrassing dispute over whether the gourd cortex should persist as a covering for cranial defects. This adaptation proved that the reconstruction of skull defects was changing, and it was extended across all surgical practice. In this period, Ibrahim bin Abdullah independently wrote a very valuable report (*Alâim-i Cerrâhîn*, AD 1505) on the possible use of a goat or dog bone graft to repair large skull defects after a fracture (Aciduman and Belen 2007). He cited Hippocrates, Galen, and Avicenna, but ignored the Western procedures on the subject. It is evident that, in that time, a method that intended to protect the brain and restore coverage in large skull defects was a desired procedure, even in other medical cultures. However, a majority of the best surgeons continued to treat fractures of the skull with bone removal, according to the precepts from ancient Greco-Roman medicine (even in the post-Renaissance period, as noted by Luca Tozzi) (Fig. 4).

The slow adoption of skull reconstruction demonstrates how difficult it was to promote the concept of brain protection. The account of Ambroise Paré, where he described how some surgeons deceived the patients and stole the gold plate, suggested grounds for a potential conflict of interest in the physician's choice of material for the surgical procedure. During the Enlightenment, and in the 19th century, the use of a silver or lead sheet was occasionally reported. Even in this period of new and improved medical care, physicians did not address the potential of toxicity from the metallic material placed over the dura mater. In 1891, von Hinterstoisser repaired a cranial defect with a celluloid plate, and in 1893, Booth used an aluminum plate, curved to fit the shape of the skull (Hinterstoisser 1891; Booth and Curtis 1893). After 1,000 years, the concept of protecting the brain after cranial bone loss had taken root; this occurred around the same time as the introduction of early neurosurgical techniques and the development of synthetic materials.

Acknowledgments

Biblioteca Complutense Universidad Madrid (Gilbertus Anglicus, Andrés Alcázar); Bibliothèque nationale de France (Guy de Chauliac, Henri de Mondeville, Johannes Scultetus); Bayerischen Staatsbibliothek (Cuba Johannes von: Cucurbita); Fondation Martin Bodmer (Cod. Bodmer 147, Estoire Del Graal); Google books search engine for all other cited texts. The authors would like to thank Lucia Ercoli and Virgo Maria for their assistance and for the translation from Latin.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

A Cruce IA. 1573. De medicamentis post operationes opportunis. In: Zilettum I, ed. Chirurgiae Ioannis Andreae a Cruce, veneti medici libri septem. Venetiis: p. 56b.

Aciduman A, Belen D. 2007. The earliest document regarding the history of cranioplasty from the Ottoman era. Surg Neurol 68:349–52.

Alcazaris A. 1575. De capitis vulneribus ab incidente telo lateralibus partibus inflictis, et an ipsis competat futura, denum de curatione. In: Portonariis D, ed. Andreae Alcazaris medici ac chirurgi guadalaxarensis in amplissima Salmanticensi Academia Chirurgae facultatis primi Professoris Chirurgiae Libri sex. Salmanticae. p. 42, 73.

Belloste A. 1696. De la maniere de panser les Playes où l'onse sert du trépan, et les autres maux de semblable nature, avec un nouvel instrument. In: D'Houry L, ed. Le chirurgien d'hôpital, enseignant une manière douce et facile de guérir promptement toutes fortes de Playes. Paris. p. 96.

Berengario I. 1535. Qualiter fit operandum cum ferramentis in laesionibus capitis ante dictis. de Nicolinis de Sabio IA. De fractura Cranii liber aureus. Venetiis. p. 108b–109.

Bertapalie. 1498. De fracturis cranei in universali. In: Locatellus B, ed. Chirurgia. Guy de Chauliac, Brunus Longoburgensis, Tura de Castello,Theodoricus Cerviensis, Rolandus, Lanfrancus Mediolanensis, Rogerius, Bertapalia. Venetiis. p. 261b.

Boerhaave H. 1728. Vulnera capitis. In: Manfrè J, ed. Praxis medica sive commentarium in aphorismos de cognoscendis & curandis morbis. Petavii. p. 556.

Booth JA, Curtis BF. 1893. Report of a case of tumor of the left frontal lobe. Ann Surg. 17:127–9.

Celsus AC. 1478. De calvariae curatione. Caput IIII. In: Nicolao, ed. De Medicina, Liber octavus. Florentiae. p. 172b–175.

Cuba J. 1485. Cucurbita. Und nennen diß Buch zu latin Ortus sanitatis uff teutsch ein Gart der Gesuntheit. Mentz. p. 88b.

Daremberg CV. 1854. De vulneribus capitis. In: Baillière JB, ed. Glossulae quatuor magistrorum super chirurgiam

Rogerii et Rolandi nunc primum ad fidem codicis mazarinei edidit. Paris. Pp. 10–35, 98.

de Lacerlata P. 1480. De signis fracture cranei et incisionis panniculorum. Genuensis B, ed. In: Cirurgie magistri Petri de Lacerlata. Venetiis. p. 47b.

Falloppius G. 1566. De curatione vulneris osse detecto. Cap. XXII. In: Bertellum L, ed. In Hippocratis librum de vulneribus capitis, Gabrielis Falloppii medici clarissimi expositio. Venetiis. p. 37a.

Galeni C. 1537. Archigenis de fissuris et contusionibus in capite factis. Froben H, ed. Opus medicum practicum, varium, vere aureum, et postremae lectionis. Claudii Galeni pergameni, medici longe omnium clarissimi de compositione pharmacorum localium, sive secundum locos, Libri decem. Basileae. pp. 53–4.

Gilbertus A. 13th century. De fractura cranei cum stricto vulnere. In: BH MSS 120. Liber morborum tam universalium quam particularium. p. 52v (105).

Grienwaldt FG. 1732. Meningophylax. In: Zipper G, ed. Novitii Gratiosi Ordinis Medicorum in Methodo Discendi Medicinam. Ingolstadii. p. 18.

Guidone de Cauliaco. 1363. De vulnere cum contusione et parva fractura ossis. In: MS Latin 7133. Inventarium chirurgicalis medicinae, libris septem: authore Guidone de Cauliaco. p. 76b.

Henrici de Amondavilla. 1306. De cura contusionis capitis cum fractura cranei absque vulnere carnis capitis exterioris. In: MS Latin 7131. Henrici de Amondavilla practica chirurgiae: pars ferè dimidia desideratur. p. 37.

Hinterstoisser H. 1891. Ueber einen durch Trepanation geheilten Fall von traumatischer Epilepsie (Jackson) nebst Bemerkungen zur Heteroplastik mittelst Celluloid. Wien klin Wochenschr 4:302–5.

Hippocratis C. 1525. De capitis vulneribus liber. In: Calvus FM, ed. Hippocratis Coi medicorum omnium longe Principis, octoginta Volumina. Romae. pp. 663–76.

Ibn Zuhr. 1497. De egritudinibus capitis accidentis ab extrinseco sicut a percussione. In: de Luna O. Liber Theizir de morbis omnibus et eorundem remediis: Antidotarium. Venetiis. Liber primus, Tract II, p. 5.

Janick J, Paris HS, Parrish DC. 2007. The cucurbits of mediterranean antiquity: identification of taxa from ancient images and descriptions. Ann Bot 100:1441–57.

Magati C. 1616. De substantia ossis deffectu. In: Dei A et B, eds. De rara medicatione vulnerum seu de vulneribus raro tractandis. Venetiis. p. 61.

Musitani C. 1698. De cranii fractura cum meningum, et cerebri vulnere. In: Cramer et Perachon, eds. Chirurgia theoretico-practica: seu trutina chirurgico-physica. Coloniae Allobrogum. p. 176.

Nuck A. 1696. De trepani applicatione. In: Boutesteyn C, ed. Operationes et experimenta chirurgica, edita per Johannis Tilingii. Lugduni Batavorum. p. 22.

Paré A. 1582. De ossium capitis corruptione et carie. Cap. XX. In: Du-Puys I, ed. Opera Ambrosii Parei regis primarii et parisiensis chirurgi. Parisiis. p. 300.

Paris HS, Daunay MC, Janick J. 2009. The Cucurbitaceae and Solanaceae illustrated in medieval manuscripts known as the Tacuinum Sanitatis. Ann Bot 103:1187–205.

Queyrats L. 1657. Quibus cautionibus, et qua arte ossa cranij fracta, vel corrupta amoveantur hac nostra aetate. In: Colomerium A, ed. Tractatus de vulneribus capitis. Tolosae. p. 185.

Sculteti J. 1656. De De apparatus et modo fonticulum supra suturam coronalem inurendi et deligandi; vulnera capitis in crucem dilatandi, et rimulas cranii dubias abradendi. In: Vlacq A., ed. ΧΕΙΡΟΠΛΟΘΗΚΗ seu D. Joannis Sculteti, physici et Chyrurgi apud Ulmenses olim felicissimi Armamentarium chirurgicum. Hagae Comitum. Tab. XXX, XXXI, p. 96.

Septalii L. 1630. Calvariae parte abscissa quod agendum. In: Frambottum P, ed. Animadversionum et cautionum medicarum. Liber octavus. Continens eas quae ad Vulnerum curationem pertinent. Patavji. pp. 54–5.

Tozzi L. 1710. De solutione continuitatis in osse. In: Porpora C et Abri N, eds. Lucae Tozzi neapolitani in librum artis medicinalis Galeni. Neapoli. p. 278.

Trollope E. 1853. Antiquities and works of art exhibited. In: Royal Archaeological Institute, ed. The Archaeological Journal. London. vol. X, p. 260b.

Troni PM. 1584. De vulneribus capitis. Bartolus H, ed. De ulceribus et vulneribus capitis. Ticini. p. 87.

van Swieten GB. 1744. Vulnera Capitis. In: Typographia Regia, ed. Commentaria in omnes Hermanni Boerhaave aphorismos de cognoscendis, et curandis morbis. Taurini. p. 444.

Verano JW, Andrushko VA. 2010. Cranioplasty in ancient Peru: a critical review of the evidence, and a unique case from the Cuzco area. Int J Osteoarchaeol 20:269–79.