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**The Hippocratic Legacy in Cranial Trauma Surgery:  
from On Head Wounds to Rogerius Frugardi's  
Chirurgia, and the Semantic Transformation of  
"Trepanation" in Scholarship**

*Anagnostis Agelarakis*

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**Περιεχόμενα**  
**EYΛIMENH 25 (2024)**

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**Περίληψεις / Summaries / Zusammenfassungen /  
Sommaires / Riassunti**

**Ευαγγελία Δήμα**, Αρχαιολογικές θέσεις και μνημεία στην Κρεμαστή και το Παραδείσι Ρόδου και η συμβολή ενός νέου υστερορωμαϊκού τάφου στον λόφο του Ασωμάτου στη μνημειακή τοπογραφία της περιοχής, *EYAIMENH* 25 (2024), 1-29.

The article examines the monumental topography (archaeological sites and monuments) of the settlements of Kremasti and Paradisi in Rhodes, as well as the contribution of a late Roman tomb recently found on the eastern slope of the Asomatos hill, which rises between the two settlements. In historical times, this area belonged administratively and geographically to ancient Ialysia, which occupied the northern end of the island and was its most important part.

The archaeological research in both settlements commenced with the Italian excavations during the interwar period, while subsequently, after the incorporation of the Dodecanese to Greece, the extensive rescue research was undertaken by the Ephorate of Antiquities of the Dodecanese. In this context, a chamber tomb was discovered, which despite its modest findings, constitutes a substantial contribution to the monumental topography of the region characterized for the most part by fertile plains that favored habitation from a very early age. The traces of its ancient inhabitants, lost in the depths of history, are identified in the abundant movable finds from the settlements of Kremasti and Paradisi, the architectural remains, the craft workshops and agricultural establishments, as well as the necropoleis scattered throughout the area of Ialysia.

**Anna Alexandropoulou**, Female acrobats in the Classical world, *EYAIMENH* 25 (2024), 31-39.

Οι εικονιστικές σκηνές αγγείων από την Αθήνα και τη Νότια Ιταλία, καθώς και ένα σύνολο κοροπλαστικών παραδειγμάτων από τη Λέσβο και τις Λιπάρες νήσους μεταξύ άλλων, συμβάλλουν στην εξέταση και την ερμηνεία του ρόλου των γυμνών ακροβάτιδων στην κλασική κοινωνία. Μολονότι η παραδοσιακή σχέση τους με τα συμπόσια και τον κόσμο των εταίρων είναι αδιαμφισβήτητη, οι εικονιστικές σκηνές της αττικής και κατω-ιταλιώτικης αγγειογραφίας, καθώς και οι αρχαίες πηγές, παρέχουν ενδείξεις για την εμφάνιση των γυμνών ακροβάτιδων και σε λατρευτικά πλαίσια, όπως για παράδειγμα στον τελετουργικό χορό *καλαθίσκο*. Δεν αποκλείεται να συνιστούν μία τελετουργική δραστηριότητα που σχετίζεται με τελετές ενηλικίωσης, δεδομένου ότι οι ακροβάτιδες, εκτός φυσικά από Διονυσιακές σκηνές, εμφανίζονται σε σκηνές που συνδέονται κυρίως με την Άρτεμη και τον Απόλλωνα.



Vases from Athens and South Italy, and statuettes from Lesbos and the Lipari islands among others, form a rich material for the examination and interpretation of the role of naked female acrobats in classical society. Their traditional connection with *symposia* and the world of *hetairai* has largely remained undisputed. A new interpretation is also possible based on the examination of figured scenes on Attic and Italian red-figure vases and literary sources. These offer evidence for the appearance of female naked acrobats in cultic contexts which include other known ceremonial acts such as the *kalathiskos* dance. Female acrobats appear in scenes chiefly connected with Artemis, Apollo and Dionysus. Therefore, we may assume that besides their evident connection with the world of spectacle, they may also form a special ritual activity related to the passage to adulthood.

**Stella Drougou**, On the occasion of a Hellenistic clay lamp from the ancient city of Aigai, Vergina, *EYΛIMENH* 25 (2024), 41-50.

Το θραύσμα ενός ελληνιστικού πήλινου λύχνου με αξιοπρόσεκτη φυτική διακόσμηση στην ανάγλυφη λαβή του, εύρημα των τελευταίων χρόνων στον ανασκαφικό τομέα «αγρός Τσακιρίδη» στη Βεργίνα, αποτελεί την αφορμή για ορισμένες παρατηρήσεις ως προς τα διακοσμητικά θέματα της μικροτεχνίας – και όχι μόνο – στην απερχόμενη ελληνιστική περίοδο. Αξίζει να σημειωθεί ότι ο ανασκαφικός τομέας «αγρός Τσακιρίδη» γειτνιάζει με το ανεσκαμμένο Μητρώο στην αρχαία πόλη των Αιγών (Βεργίνα), στα ΒΔ αυτού. Στον υπό έρευνα ακόμη χώρο έχουν αποκαλυφθεί κυρίως τα οικοδομικά λείψανα εργαστηριακών εγκαταστάσεων καθώς και χαρακτηριστικά κινητά ευρήματα, κατάλοιπα βιοτεχνικών προϊόντων.

The fragment of a Hellenistic clay lamp with a remarkable relief handle, a recent find from the excavational sector “Tsakiridis field” in Vergina, gave rise to some observations on the decorative motives of Hellenistic handcrafts products. It is noteworthy, that the site “Tsakiridis field” lies in the vicinity of the excavated Metroon in the ancient city of Aigai (Vergina), where remains of workshops as well as other finds, products of their workmanship, are significantly substantiated.

**Γεώργιος Κ. Καλλής**, Επτά κλίβανοι από τον νομό Κορινθίας, *EYΛIMENH* 25 (2024), 51-78.

The subject of this essay are the ceramic kilns that were identified and investigated in the region of Corinth. Two kilns were excavated in the area of ancient Sikyon and date back to the Hellenistic era and five kilns were discovered at Kamari of the municipality of Xylokastro, dated to the Roman period. In addition to the structural and functional elements of the kilns, the ceramic finds resulting from the excavation are also examined. The study of these humble monuments is a useful tool for reconstructing the social and economic organization of the ceramic workshop during antiquity and contributes to the promotion of the kilns’ research in the region of the Peloponnese.

**Anagnostis Agelarakis**, The Hippocratic Legacy in Cranial Trauma Surgery: from *On Head Wounds* to Rogerius Frugardi's *Chirurgia*, and the Semantic Transformation of "Trepanation" in Scholarship, *EYAIMENH* 25 (2024), 79-93.

Στην ιστορία της ιατρικής, η Ιπποκρατική πραγματεία *Περί Των Εν Κεφαλῇ Τρωμάτων* αποτελεί την αρχαιότερη γραπτή πηγή της χειρουργικής αντιμετώπισης καταγμάτων κρανίου λόγω τραυματισμού. Πολλές σύγχρονες επιστημονικές δημοσιεύσεις αναφέρονται στις Ιπποκρατικές κρανιο-χειρουργικές μεθόδους, υπογραμμίζοντας τη σημασία τους στην ιστορία της ιατρικής. Συχνά συγκρίνουν τις Ιπποκρατικές πρακτικές με αρχαιο-παθολογικές περιπτώσεις κρανιο-χειρουργικών επεμβάσεων σε διαφορετικές περιόδους και περιοχές από τη Νεολιθική Εποχή και εφεξής. Ωστόσο, ορισμένα σχόλια που διατυπώνονται εκ των υστέρων, μετά από δύο και πλέον χιλιετίες, είναι ανακριβή ή ελλιπή. Σπανίως δε, αποδίδονται στον Ιπποκράτη εικασίες για ελλείψεις στη μεθοδολογία ή στις εμπειρικές του γνώσεις και δεξιότητες, βασισμένες ενδεχομένως σε ατελή μελέτη ή παρερμηνεία της πρωτογενούς ιστορικής πηγής, αλλά και σε ό,τι αφορά στον όρο «τρυπανισμός», που υιοθετήθηκε τον 19ο αιώνα και περιλαμβάνει κάθε άνοιγμα στο κρανίο μέσω χειρουργικής επέμβασης.

Το άρθρο διερευνά πτυχές της Ιπποκρατικής πραγματείας, εστιάζοντας στις χειρουργικές διαδικασίες, τις τεχνικές και τα εργαλεία που χρησιμοποιήθηκαν, με παράθεση αποσπασμάτων αρχαίων κειμένων. Επιπλέον, προσφέρει μια διαχρονική ανάλυση από τον 5ο αι. π.Χ. έως την Αναγέννηση, αναδεικνύοντας τη σημασία της Ιπποκρατικής κληρονομιάς και καταδεικνύοντας τις επιστημονικές ανακρίβειες που προκύπτουν από την ελλιπή μελέτη του θέματος και την καθολική χρήση του όρου «τρυπανισμός» στη σύγχρονη αρχαιο-ανθρωπολογική βιβλιογραφία.

The Hippocratic treatise *On Head Wounds* (*Περί Των Εν Κεφαλῇ Τρωμάτων*) stands as the earliest recorded account of surgical techniques for cranial fractures resulting from trauma. Its descriptions of surgical procedures, tools, and methodologies have been widely referenced in modern medical and archaeological scholarship. Researchers frequently compare these Hippocratic practices with evidence of cranial surgery observed across various historical and cultural contexts, from prehistoric times through antiquity. Despite its historical importance, interpretations of the treatise are sometimes shaped by modern assumptions rather than a faithful reading of the original text. Certain retrospective analyses, written more than two millennia later, present incomplete or inaccurate assessments, often due to misinterpretations of the primary source. These studies occasionally attribute deficiencies in surgical methodology or empirical knowledge to Hippocrates himself. Additionally, the 19th-century introduction of the term *trepanation*—which has come to encompass all surgically induced cranial openings—has contributed to a generalized and often misleading classification of ancient surgical practices.

This article revisits the surgical concepts outlined in *On Head Wounds*, focusing on operative techniques, instrumentation, and textual evidence. It also examines the evolving interpretation of these procedures from antiquity to the Renaissance, emphasizing the need for greater precision in discussing Hippocratic contributions and the impact of terminological imprecision on archaeo-anthropological discourse.



# THE HIPPOCRATIC LEGACY IN CRANIAL TRAUMA SURGERY: FROM *ON HEAD WOUNDS* TO ROGERIUS FRUGARDI'S *CHIRURGIA*, AND THE SEMANTIC TRANSFORMATION OF “TREPANATION” IN SCHOLARSHIP

## Introduction

In the history of medicine, the Hippocratic treatise *On Head Wounds*<sup>1</sup> provides the earliest written account of a surgical process for treating trauma-impacted-fractured cranial bones. Consequently, numerous recent scholarly publications on the subject matter refer to the Hippocratic cranial surgical methods, emphasizing their historical significance. These works often refer to the Hippocratic procedures, while comparing with archaeo-pathological cases of cranial surgeries across different periods and regions from the Neolithic onward. Occasionally, however, comments are made in these works, which in hindsight of nearly two and a half millennia are neither precise<sup>2</sup> nor equitable<sup>3</sup>. In rare circumstances, conjectures are imputed to Hippocrates himself suggesting shortcomings in the methodology of performing and completing the intervention<sup>4</sup>, lack of experiential knowledge and surgical skills<sup>5</sup>, comments possibly based on an incomplete study or an inadequate understanding of the primary historical source –while focusing on what has come to be encompassed in literature by the term *trepanation*. The term was adopted in archaeo-anthropological contexts during the late 19th century to include any opening in the cranium through surgical intervention.

This article aims to address and illuminate aspects of the *On Head Wounds* recommended surgical process, focusing on the surgical procedures, the techniques, and the instruments used to carry out the intervention, including for reference sample excerpts of the ancient text with careful translations. Furthermore, the paper intends to offer a diachronic narrative on the foundational nature of the Hippocratic treatise regarding surgical interventions to treat cranial bone fractures, as documented by historical sources, spanning from the 5th c. BC to the post-Renaissance period, culminating with the 19th-century adoption of the term “trepanation”; a semantic shift which engenders inaccuracies

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<sup>1</sup> Hippocrates, III, i-xxi (ed. É. Littré, *Oeuvres complètes d'Hippocrate*, vol. 3, Paris 1841, repr. Amsterdam: Hakkert, 1961).

<sup>2</sup> Often overlooking the fact that the treatise was compiled, as clearly stated by its title, to address head trauma and the treatment of cranial bone fractures, rather than cranial surgery in reference to other pathological etiologies in antiquity.

<sup>3</sup> If we consider that the remarkable progress of modern medical science may inadvertently obscure our appreciation of the limitations and challenges faced by the ancient practitioners in conducting the surgical process.

<sup>4</sup> On the recommendations dictating specific steps to be carried out in performing the surgical process.

<sup>5</sup> Cf. Krivoschapkin *et al.* 2014.

and oversimplifications in archaeo-anthropological discourse when used for comparisons with the nuanced methodologies and context-specific recommendations of the Hippocratic treatise.

### **The Hippocratic surgical process for treating cranial fractures in *On Head Wounds***

The Hippocratic recommendations for cranial injury intervention in the treatise *On Head Wounds* align with a carefully structured medico-surgical process, referring to comprehensive diagnostic evaluations and carefully administered preoperative procedures according to the condition of the patient, the causes and circumstances of traumatism, the nature of the head wound, and a meticulous examination on the severity of the injury or fracture at the impact locus<sup>6</sup>, inclusive of a unique technique for the investigation to trace and identify the potential of latent radiating fissure-fractures<sup>7</sup>. Subsequently, detailed guidance is provided regarding the surgical operation, with recommendations for the selection of preferred surgical techniques<sup>8</sup> based on the cranio-anatomic location and specific condition of the wound, with an emphasis on judicious care and the implementation of prophylactic measures during the surgeon's technical actions in the procedure, to prevent iatrogenic osseous trauma caused by improper handling, to minimize the risks for infection and injury to the dura mater<sup>9</sup> and its substratal tissues, thereby improving the patient's chances for recovery and healing.

In *On Head Wounds*, the nuanced approach, presented authoritatively and replete with precise guidance and elaboration on the appropriate and cautionary actions required throughout the surgical process, involves the entire sequence of steps from the evaluation of the wounded, the diagnosis and decision-making for the preoperative preparation and the surgical technique to be implemented for the procedure itself, as well as the post-surgical follow-up with the patient. It reflects the Hippocratic experiential knowledge and deep understanding of: 1) cranial anatomy and physiology (xvii, 10-21)<sup>10</sup>; 2) cranial morphologic variability in relation to the patient's age and biological developmental status (xviii, 1-10, 19-21); 3) the variability of head injuries classified under five subcategories of skull injury that may be sustained in relation to the context of circumstances, the typology of the striking weapon, and the mode of impact (iii-viii; xi); 4) diagnostic investigations and assessments on the nature, complexity, and severity of the trauma (ix-x; xiii; xiv, 47-49); 5) preoperative preparation and application of pharmaceuticals (xiii, 22-50; xiv, 1-13); 6) advice on the

<sup>6</sup> Referred to in the ancient text as *ἔδρη*, “seat or base imprint of the impact”; see Hanson 1999, 100-101.

<sup>7</sup> Essentially simulating an early *imaging* technique of the period (xiv, 46-50).

<sup>8</sup> Providing guidance to the surgeon on how to proceed if he is the first to treat the patient or receives the patient following unsuccessful treatment by another practitioner.

<sup>9</sup> The Hippocratic treatise *On Head Wounds* predates the discovery and introduction of the *meningophylax* in craniotomy procedures, first mentioned by Celsus [*De Medicina (On Medicine)* 8.3.3] and later by Galen as the *meningophylax* [*Περὶ Ἀνατομικῶν Ἐγχειρήσεων (On Anatomical Procedures)*, 2, 686K (ed. C.G. Kühn, *Claudii Galeni opera omnia*, vol. 2, Leipzig: Knobloch, 1821, repr. Hildesheim: Olms, 1964)], and as “the flat end of the lentiform guard” [*Θεραπευτικὴ Μέθοδος (Method of Medicine)*, 10, 448K-450K (ed. C.G. Kühn, *Claudii Galeni opera omnia*, vol. 10, Leipzig 1825, repr. Hildesheim: Olms, 1965)]. For chronological context, Hippocrates, who lived between ca 460-375 BC (see Agelarakis 1997), preceded by 350 years at the end of his life the birth Celsus (ca 25 BC-50 AD) and by 504 years the birth of Galen (see Agelarakis 1997a), who lived between 129 and 216 AD.

<sup>10</sup> Where also the anatomical term *τῆς διπλῆς τοῦ ὀστέου*, “of the diploe of the cranial bone”, is introduced (xvii, 11), along with *τοῦ ὀστέου ἄμφω αἱ μοῖραι... ἢ τε ἄνω μοῖρη τοῦ ὀστέου καὶ ἡ κάτω*, rendered as “both tables of the cranial bone... the upper table of the cranial bone and the lower one” (xvii, 17-19).

selection of surgical techniques<sup>11</sup> for the treatment of cranial bones as rendered appropriate according to the condition of the fracture (xii, xvii, 1-8; xiv, 3-66; xviii, 11-21; xix, 33-39; xxi, 1-33); 7) cautionary advice on the proper implementation of tool use during the surgical procedure (xxi, 18-55); 8) advice on prophylactic measures concerning matters of patient safety (xiii, xv, 4-18; xvii, 7-10; xix, 5-39); 9) postoperative therapeutic care (xiii, 1-21; xv, 1-35; xx, 1-17); and 10) the potential risks of patient morbidity, and mortality (xix, 1-32).

### **The first systematic medico-surgical protocol for treating cranial fractures in *On Head Wounds***

Upon careful examination of the passages of the treatise *On Head Wounds*, it becomes clear that it refers to explicit methods and skills necessary for the surgeon to perform specific, and in some cases, multiphase actions during the surgical operation, encompassing diverse tools, dexterous and precise movements, and careful surgical maneuvers required for the technical execution of the procedure. Furthermore, the treatise refers to and strongly recommends specific guidelines to be followed during the surgical process, from preoperative to postoperative care, cautioning, with reference to evidence-based practices, about patient safety, the safe handling of surgical instruments, and endorsing surgical time-outs (xxi, 18-27), promoting consistency and enhancing surgical efficiency. In overview, the treatise generates a set of conditions, guidelines, and precautions to be followed by the surgeon, encouraging reduced variability and fostering the standardization of procedures or rules for conducting the surgical process, thus reflecting what could be designated in modern times as a systematic surgical protocol for the treatment of cranial fractures.

### **Sample excerpts of *On Head Wounds*, contextualizing recommendations on the implementation of procedures and techniques during the surgical operation**

Regarding the recommendations on the surgical operation, as part of the broader surgical process to treat cranial fractures, *On Head Wounds* distinguishes between the scraping<sup>12</sup> technique using the raspator<sup>13</sup>, the sawing<sup>14</sup> technique using the circular denticulate saw, and drilling using the perforating trepan<sup>15</sup>. These three surgical techniques are carefully articulated, with clear explanations of the reasons for selecting, or where relevant combining them to perform the cranial surgical operation to treat wounded bone as may be required following the diagnostic and preoperative stages.

The following excerpts, sampled from the Greek text<sup>16</sup> *On Head Wounds*, with English translations<sup>17</sup>, aim to offer precise insight into the cranial surgical process to treat cranial

<sup>11</sup> And/or a combination thereof.

<sup>12</sup> The verb used in this context of the Hippocratic treatise is *ἐπιξύω*, “to scratch/to scrape”, and the noun is *ξύσις*, “the scraping” (see Hanson 1999, 106).

<sup>13</sup> The noun used in the treatise is *ξύστηρ*, “scraper/rasp/file” (see Hanson 1999, 106).

<sup>14</sup> The verb used in the Hippocratic treatise is *πρίω*, “to saw” (see Hanson 1999, 106, 117), the noun is *πρίων*, “a toothed saw/a saw of teeth”, rotated by a strap (see Hanson 1999, 106, 118), and deriving from that is *πρίωσις*, “a sawing”.

<sup>15</sup> The noun used in the treatise for the tool is *τρύπανον*, “drill/borer/auger”, rotated by a strap, while the verb is *τρύπῳ*, “to bore/to pierce through” (see Hanson 1999, 106, 118).

<sup>16</sup> The ancient Greek text “...mainly that of Petrequin...” derives from Hippocrates’ *On Wounds in the Head*.

<sup>17</sup> The English translations are of the present author, adhering as closely as possible to the formal register, tone, and nuance of the original Greek text.

fractures. These passages reflect the detailed Hippocratic recommendations, technical guidelines, and cautionary advice, aimed at guiding the surgeon – ostensibly the novice – through the endorsed procedures involved in the surgical operation while capturing the instructive style and distinctive tone of the Hippocratic teaching.

I. The following excerpt of the treatise refers to the surgical technique of scraping by the raspatory, investigating the potential of latent fissures and/or contusions, along with recommendations for implementing the sawing technique with the circular denticulate saw, if required:

“τῇ δ’ ὑστεραίῃ ἡμέρῃ, ἐπειδὴν ἐξέλῃς τὸν μοτὸν, κατιδὼν τὸ ὀστέον ὃ τι πέπονθεν, ἐὰν μὴ σοι καταφανῇς ἢ ἡ τρῶσις, ὁκοίῃ τίς ἐστὶν ἐν τῷ ὀστέῳ, μηδὲ διαγινώσκῃς εἴ τί τι ἔχει τὸ ὀστέον κακὸν ἐν ἐωυτέῳ, ἢ καὶ οὐκ ἔχει, τὸ δὲ βέλος δοκέῃ ἀφικέσθαι ἐς τὸ ὀστέον καὶ σίνασθαι, ἐπιξύνειν χρὴ τῷ ξυστήρι κατὰ βάθος καὶ κατὰ μήκος τοῦ ἀνθρώπου ὡς πέφυκε, καὶ αὐθις ἐπικάρσιον τὸ ὀστέον, τῶν ῥηξίων εἵνεκα τῶν ἀφανέων ἰδεῖν, καὶ τῆς φλάσιος εἵνεκα τῆς ἀφανέος, τῆς οὐκ ἐσφλωμένης ἔσω ἐκ τῆς φύσιος τῆς κεφαλῆς τοῦ ἄλλου ὀστέου. Ἐξελέγχει γὰρ ἡ ξύσις μάλα τὸ κακὸν, ἢν μὴ καὶ ἄλλως καταφανέες ἔωσιν αὐταὶ αἱ πάθαι ἐοῦσαι ἐν τῷ ὀστέῳ. Καὶ ἢν ἔδρην ἴδῃς ἐν τῷ ὀστέῳ τοῦ βέλεος, ἐπιξύνειν χρὴ αὐτὴν τε τὴν ἔδρην, καὶ τὰ περιέχοντα αὐτὴν ὀστέα, μὴ πολλάκις τῇ ἔδρῃ προσγένῃται ῥῆξις καὶ φλάσις, ἢ μούνη φλάσις, ἔπειτα λανθάνῃ οὐ καταφανέα ἐόντα. Ἐπειδὴν δὲ ξύσης τὸ ὀστέον τῷ ξυστήρι, ἢν μὲν δοκέῃ ἐς πρίσιον ἀφίκειν ἡ τρῶσις τοῦ ὀστέου, πρίειν χρὴ, καὶ οὐ δεῖ τὰς τρεῖς ἡμέρας μὴ ὑπερβάλλειν ἀπρίωτον, ἀλλ’ ἐν ταύτῃσι πρίειν, ἄλλως τε καὶ τῆς θερμῆς ὥρης, ἢν ἐξ ἀρχῆς λαμβάνῃς τὸ ἴημα” (xiv, 13-37).

*“At the next day, whenever you remove the lint, while you observe for any defects on the (cranial) bone, if the damage of what the bone sustained is not clear to you, and you cannot diagnose if the bone has been harmed or not, while the weapon is considered to have reached and harmed the bone, you need to scrape it down with the rasp up and down<sup>18</sup>, according to the long axis of the human, and in turn transversally in order to be able to recognize the latent bone fissure breakings and the latent crushing/bruising on account it is not crushed inwards from the natural form of the other (adjacent-peripheral) cranial bone. For the rasping puts well to proof the harm, while not clearly distinguishable even though they exist in the bone. And should you see the locus of impact (ἔδρην) by the missile<sup>19</sup> in the bone, you need to scrape the locus of impact (ἔδρην) and the bones that contain it, lest as in many times to the locus of impact (ἔδρην) go together a fissure break and crushing/bruising, or crushing/bruising alone, yet it is missed if not revealed. Whenever you scrape the bone with the raspatory, in case it is considered that the damage of the bone needs sawing, don’t exceed three days without sawing him (the wounded), but saw within this interval, particularly during the warm period (of the year), if you undertake from the beginning the medical treatment”.*

II. This excerpt of the treatise reflects on the relationship between multiple procedures during the surgical operation, including the diagnostic method for investigating latent fractures, the surgical techniques of scraping with the raspatory and sawing with the circular denticulate saw:

<sup>18</sup> Βάθος is translated both as: a) in a context relevant to movement, as “up and down” (hence, in the anatomic context of a human patient as of a proximal and distal direction), and b) as “in depth/depth”.

<sup>19</sup> Βέλος is translated as “missile/swift-darting object/arrow”, and even as a “hurled rock fragment”. In other contexts it may be translated as “weapon”.

“ἦν μὴ διαγινώσκης εἰ ἑρρώγε τὸ ὀστέον, ἢ πέφλασται, ἢ καὶ ἀμφοτέρω ταῦτα, μήτε ὅλως ὄραν δύνη, δεῖ δὴ, ἐπὶ τὸ ὀστέον τὸ τηκτὸν τὸ μελάντατον δεύσαντα, τῷ μέλανι φαρμάκῳ τῷ τηκομένῳ στεῖλαι τὸ ἔλκος, ὑποτείναντα ὀθόνιον, ἐλαίῳ τέγξαντα, εἴτα καταπλάσαντα τῇ μάζῃ ἐπιδῆσαι· τῇ δ’ ὑστεραίῃ, ἀπολύσαντα, ἐκκαθήραντα τὸ ἔλκος, ἐπιξῦσαι. Καὶ ἦν μὴ ἡ ὑγιὲς, ἀλλ’ ἐρρώγη καὶ πεφλασμένον ἦ, τὸ μὲν ἄλλο ἔσται ὀστέον λευκὸν ἐπιξυόμενον· ἡ δὲ ῥωγμὴ καὶ ἡ φλάσις, κατατακέντος τοῦ φαρμάκου, δεξαμένη τὸ φάρμακον ἐς ἐωυτὴν μέλαν ἐὼν, ἔσται μέλαινα ἐν λευκῷ τῷ ὀστέῳ τῷ ἄλλῳ. Ἀλλὰ χρὴ αὖθις τὴν ῥωγμὴν ταύτην φανεῖσαν μέλαιναν ἐπιξέειν κατὰ βάθος· καὶ ἦν μὲν ἐπιξύων τὴν ῥωγμὴν ἐξέλῃς καὶ ἀφανέα ποιήσῃς, φλάσις μὲν γεγένηται τοῦ ὀστέου ἢ μᾶλλον ἢ ἥσσον, ἣτις περιέρρηξε καὶ τὴν ῥωγμὴν τὴν ἀφανισθεῖσαν ὑπὸ τοῦ ξυστήρος· ἥσσον δὲ φοβερὸν καὶ ἥσσον ἂν πρῆγμα ἀπ’ αὐτῆς γένοιτο ἀφανισθείσης τῆς ῥωγμῆς. Ἦν δὲ κατὰ βάθος ἡ καὶ μὴ ἐθέλῃ ἐξιέναι ἐπιξυομένη, ἀφίκει ἐς πρίσιν ἢ τοιαύτη ξυμφορὴ” (xiv, 46-66).

*“In case you are unable to form a diagnosis if the (cranial) bone is fractured or crushed/bruised, or both of those, and you are otherwise unable to perceive that, it is necessary in fact to wet the bone (with) the darkest melted preparation (and to) apply the black molten drug on the wound, stretching under/putting under a piece of fine linen moistened with olive oil. Next, plaster over with the barley preparation<sup>20</sup> and bandage. In the next day having released and cleansed out the wound, scrape (the surface of the skull). And if it (the bone) is not healthy, but is fractured and crushed, the other (rest) of the bone will be white as it is scraped. Meanwhile the fracture and the crushing, having received inside it the dissolved drug would itself be black, being black within the other/rest of the white bone. But it is necessary in turn to scrape in depth this black appearing fracture. And if indeed, by scraping you remove it and make it invisible, it was just about a crushing/bruising that happened to the bone that caused the fracture (which was) obliterated by the raspatory. Less dreaded and less complications would have likely risen from it, as the fracture was removed. If on the other hand (the fracture) exists in depth, and is unwilling to recede while scraped, this plight is a case for sawing”.*

III. The next two excerpts offer insight of the drilling technique by the *τρίπανον*, “trepan”, performed during the surgical procedure:

III.i. “ἀλλὰ χρὴ, ἦν ψιλωθῇ τῆς σαρκὸς τὸ ὀστέον, προσέχοντα τὸν νόον, πειρῆσθαι διαγινώσκειν ὃ τι μὴ ἔστι τοῖσιν ὀφθαλμοῖσιν ἰδεῖν, καὶ γινῶναι εἰ ἑρρώγε τὸ ὀστέον καὶ εἰ πέφλασται, ἢ μούνον πέφλασται, καὶ εἰ, ἔδρης γενομένης τοῦ βέλεος, πρόσσεστι φλάσις, ἢ ῥωγμὴ, ἢ ἄμφω ταῦτα· καὶ ἦν τι τούτων πεπόνθη τὸ ὀστέον, ἀφεῖναι τοῦ αἵματος τρυπῶντα τὸ ὀστέον σμικρῷ τρυπάνῳ, φυλασσόμενον ἐπ’ ὀλίγον· λεπτότερον γὰρ τὸ ὀστέον, καὶ ἐπιπολαιότερον τῶν νέων ἢ τῶν πρεσβυτέρων” (xviii, 11-21).

*“But it is necessary, in case the bone is stripped bare of flesh, being careful of the mind (being mindful/with prudence), endeavor/attempt to discern/determine that which cannot be seen by the eyes, and to know if the bone fractured and if it bruised/crushed, or only bruised/crushed, and if, it came into being a locus of impact (ἔδρη) by the missile, adjacent will be crushing/bruising or fracture or both of them. And if by any of those suffered the bone, get rid of/discharge/let go of the blood perforating the bone with the small/little trepan, a little at a time keeping watch and guard, for thinner is the bone of the young than of the older”.*

<sup>20</sup> Cf. Agelarakis *et al.* 2020.



III.ii. “ἦν δὲ τρυπάνω χρῆ, πρὸς δὲ τὴν μήνιγγα μὴ ἀφικνέεσθαι, ἦν ἐξ ἀρχῆς λαμβάνων τὸ ἦμα τρυπᾷς, ἀλλ’ ἐπιλιπεῖν τοῦ ὀστέου λεπτόν, ὥσπερ καὶ ἐν τῇ πρίσει γέγραπται” (xxi, 51-55).

*“In case the use of the perforating trepan is wanted/desired/required, do not reach/avoid reaching to the membrane, in case having received/undertaken from the beginning the medical treatment you perforate, but leave behind a thin layer of bone, just/like as has been recorded/written for the sawing”.*

### **Cranial fractures and surgical legacy from Hippocrates (5th c. BC) to Rogerius Frugardi of Salerno (12th-13th c. AD)**

Of the surgical techniques in *On Head Wounds*<sup>21</sup>, the cylindrical toothed saw used in sawing (πρίωσις) during the time of Hippocrates should have been rotated by a strap, similar to a cord on a bow, as referenced by Celsus<sup>22</sup> (VIII, 3, 2-3 and 7), and later by Heliodorus the surgeon<sup>23</sup>, referring to the trepan that was to be rotated through what he names the ἀρίς, “bow-drill”<sup>24</sup>, which was to be operated cautiously in variable speeds, according to the positional depth of the trepan edge in the diploic component<sup>25</sup>. The specific account is preserved in Oribasius (46.11.5-10, 220).

However, in Galen’s *Method of Medicine* where he elaborates on and refines what he perceives as stated vaguely by Hippocrates, while supplementing the Hippocratic treatise with knowledge gained through later discoveries, the term πρίωσις (sawing) is notably absent<sup>26</sup>, in contrast to the continued recommendations for the scraping and drilling surgical

<sup>21</sup> By scraping ξύσις with the raspatory, sawing πρίωσις with the cylindrical toothed saw, and piercing through with the drill τρύπανον.

<sup>22</sup> Celsus (ca 25 BC-50 AD), a distinguished Roman polymath, encyclopedist, and medical practitioner –contrary to claims that he was merely an encyclopedist– provides in his eight-volume medical treatise *De Medicina* (*On Medicine*) valuable insight representative of Alexandrine Medicine (Book 1, *Prooemium* 8; Book 7, *Prooemium* 3), of which unfortunately the majority of primary records have been lost. The thematic units he addresses align with the three Greek subdivisions of the Art of Medicine [Διαιτητικήν, “(healing by the) dietary intake”, Φαρμακευτικήν, “(curing by) pharmacopoeia”, and Χειρουργία, “working (curing) by the hand”, cf. *De Medicina*, Book 1, *Prooemium* 9]. The treatise addresses dietary matters, causative agents and treatment of disease (Books 1-4), medicaments, internal remedies, and prescriptions (V), and for the “*Tetrium esse medicinae partem, quae manu curet*”, “*The third part of the Art of Medicine is that which cures by the hand*” (VII, *Prooemium* 1) on dislocations, surgical interventions as well as wound and fracture treatment (Books 7 and 8).

<sup>23</sup> Heliodorus lived in the 1st c. AD. He was a member of the Πνευματικοί (Pneumatists), School of Medicine, as recorded by Galen in *Περὶ διαφορᾶς σφυγμῶν* [*De Different Pulse* II (ed. C.G. Kühn, *Claudii Galeni opera omnia*, vol. 8, Leipzig: 1824, repr. Hildesheim: Olms, 1965)] (cf. Johnston and Papavramidou 2024).

<sup>24</sup> Whereby he states that the acoustic pores (external auditory canals) of the patient were to be occluded to mitigate the auditory perception of the trepanation process, thereby reducing his psychological distress.

<sup>25</sup> Heliodorus provides a splendid record of detailed medico-surgical thematic descriptions and recommendations on cranial fracture treatment, revealing a continuum of the Hippocratic methodologies with refinements, preserved in Oribasius’ Medical Collections XLVI (ed. J. Raeder, *Oribasii collectionum medicarum reliquiae*, vols. 1-4, Corpus medicorum Graecorum 6.1.1-6.2.2. Leipzig: 1928-1933) involving the following Chapters: *On Head wounds, Healing treatment of wounds, On large wounds with denuded bones, On fractures, On fissures, On incisions, On fractures with elevated bone fragments, On depressed fractures, On cranial fracture with a bone fragment that slips under the diploic component, On purulent bones, On contusions, On the sizes of the sutures, Healing treatment of perforated bones, and On the inflammation of the meninx.*

<sup>26</sup> A rare comment on the discontinued use of saws in cranial surgery is referenced by Paul of Aegina, the Byzantine Greek philosopher-travelling physician of the 7th c. AD, in Section *Περὶ τῶν ἐν τῇ κεφαλῇ καταγμάτων*, (*Regarding the fractures on the head*), in the sixth book on surgery of his treatise, *Ἐπιτομή Ἰατρικῆ* (*Medical*

techniques, whereby a variety of *ξυστήρων*, “raspatories”, and *τρύπανων*, “drills/trepan”, are required, respectively (10, 445K-447K). Regarding the latter, Galen describes that some of the perforating drills, the so-called *ἀβάπτιστα τρύπανα*, “non-dipping/plunging drills”, are equipped with an external guard-ring on their cylindrical exterior to prevent the sharp end of the drill from plunging into the dura mater while drilling through the diploe (10, 447K).

While the use of *τρύπανα*, “drills/trepan”, to perform the operation is of importance in the Galenic treatise, he also notes that some of the more cautious/timid practitioners employ the *χοινικίς*, “hollow cylindrical denticulate saw”, equipped with a central pin to ensure a precise grip and positioning on the cranial bone surface, thereby avoiding slippage (10, 448K). Yet, chronologically preceding Galen, Celsus in *De Medicina* provides a detailed reference to this instrument, naming it *modiolus* in Latin, and noting that the Greeks call it *χοινικίς* (8.3.1). He describes it as being rotated like a trepan, using a strap, but explains that once it has cut to a shallow depth through the cranial bone, the central pin may be removed, allowing the *modiolus* or the *χοινικίς* to be operated without it<sup>27</sup>. In the same passage, while he describes the form and shape of the trepans, he explains that the *modiolus* may be used for smaller excisions of cranial bone, whereas larger excision interventions require the use of *terebra*, “trepans”. Celsus explains that the trepans are employed in this intervention to drill adjacent holes on the healthy margins surrounding the entire targeted area of bone which is to be excised. Subsequently, a surgical mallet (*malleolo*) is used to strike with a chisel-like tool (*excissorius scalper*) the intervening boundaries between each hole to excise the encircled bone. He continues by noting that the surgical opening generated by this technique may roughly simulate the imprint made by a *modiolus*, although the trepans in such a case produce a larger ring-like opening (8.3.3-5).

Notably, from the time of Hippocrates and Galen through Classical Antiquity to the Early Middle Ages, advances in medical concepts and methodological approaches to cranial trauma care ushered in noteworthy improvements in surgical practice<sup>28</sup>. These advancements also led to the discontinuation of certain surgical techniques, such as *πρίωσις* and the use of *χοινικίς* or *modiolus*, as evidenced by a reference from the Byzantine period of the 7th c. AD. This reference clearly reveals that both practices had fallen out of favor among surgical practitioners, as stated by Paul of Aegina, *Medical Epitome* 6.90.7 “ἡ δὲ διὰ τῶν πριόνων τε καὶ χοινικίδων χειρουργία τοῖς νεωτέροις ὥς μοχθηρὰ διαβέβληται”, “the surgery by saws and choinikis is clearly regarded by the younger (surgeons) as ineffective/of suffering hardship”. On the contrary Paul of Aegina clearly reveals the continued use of trepans, of scrapping, cutting, and smoothing instruments in the surgical techniques to treat cranial trauma. The following passage, of the segment *Χειρουργία (Surgery)*, in the sixth book of his treatise, offers a translated rendering<sup>29</sup>, with occasional insertions of explained Greek terms (6.90.4-6). “In the case the cranial bone was to be weak, out of its own nature or due to the trauma impact, initially peeling chisels were to be used from wider to narrower sizes to remove bone, followed by lenticular cutting instruments operated by gentle mallet strikes to avoid shaking the head of the patient. In case the bone was strong the so-called non-

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*Epitome* 6.90.7 (ed. J.L. Heiberg, *Paulus Aegineta*, 2 vols., Corpus medicorum Graecorum 9.1 & 9.2. Leipzig 1921-1924).

<sup>27</sup> Basma *et al.* 2023, fig. 5.

<sup>28</sup> Salazar 2000; Scarborough 2010; Agelarakis 2014, 2020; Nutton 2024.

<sup>29</sup> Translated by the author.

plunging (trepan) (ἀβαπτίστοις λεγομένοις), would be used to perforate around the wound (περιτρυπήσαντες), then using the excising knives for the extirpation/excision of the affected bone fragments, bone removal is performed incrementally, if possibly by the fingers, otherwise by the dental forceps (όδοντάγρα), or the bone forceps (όστάγρα), or the hair tweezer/pincer (τριχολαβίς). The space in between the perforated openings should be like that of the widest core of a probe<sup>30</sup>, while their depth (should be) near the deepest surface of the endocranial table, taking caution for the trepan (τρύπανον), not to touch the meninx. Therefore, several trepans should be prepared to match the (required) thickness of the bone (of the patient). And if the fracture involves just the cranial diploe no further perforation is needed. Following the care of the bone, smoothening the roughness of the cranial bone caused by the excision using the raspatory, or one of the rounded excising blades (μηλιωτῶν ἐκκοπεῖς), supported by the *meningophylax* (inserted under the diploe for protection of the meninx—dura) and removing the likely remaining tiny bone fragments or flakes, advantageously we are going to/proceed to/attend to/provide for the wound dressing. This is the most common, yet also easily handled and free from danger manner of surgery, along with the exceedingly praised by Galen (surgical) manner named by the lenticular knife (φακωτός), without circum-perforation (of the wound) by trepans, the smoothening (of the cranial bone) undertaken by the excising/peeling chisels (κυκλίσκοι)<sup>31</sup>.

In this section of his treatise (6.90.6-7), Paul of Aegina inserts, for accuracy and reference, two quotations from Galen's *Method of Medicine*. The first quote<sup>32</sup> provides a core segment of Galen's detailed description (cf. *Method of Medicine*, 10, 448K-449K) of how to perform the aforementioned surgical procedure. Paul of Aegina also notes that this operation is the best surgical approach for cranial fractures, as in fact had been asserted by Galen: αὕτη μὲν οὖν ἀρίστη χειρουργία τῶν ἐν τῷ κρανίῳ καταγμάτων, "this one, then, is the finest surgical procedure for fractures on the cranium" (*Method of Medicine*, 10, 450K). For the second quotation<sup>33</sup>, Paul of Aegina prefaces it by highlighting its didactic value, where Galen provides guidance on the extent and amount of bone to be excised from the cranial fracture, in relevance to the intervention (cf. *Methods of Medicine*, VI, 6, 450K).

It is evident in the *Medical Epitome* 6 of Paul of Aegina, particularly in the sections *Regarding the Fractures on the Head* and *Surgery*, that some advancements in methodology, surgical procedures, and instrument use are present. However, the influence of an unreferenced Heliodoric and referenced Galenic continuum of medico-surgical practices on cranial fracture treatment is distinctly evident. Remarkably, there is a conspicuous absence of Roman terms, approaches, techniques, or tools associated with cranial trauma surgery. This absence suggests a diminished regard for surgical interventions

<sup>30</sup> A long thin medical instrument to diagnose wounds, cf. Hippocrates (III, x, 13).

<sup>31</sup> See Papadakis *et al.* 2015, 3, fig. 2 (an ostagra), and Table 1, no 66 (όδοντάγρα), no 70 (όστάγρα), no 106 (τριχολάβιον), no 107 (τρύπανον), no 56 (μηγιγοφύλαξ), no 54 (μηλιωτὸς ἐκκοπεύς), no 113 (φακωτὸς ἐκκοπεύς), no 47 (κυκλίσκος).

<sup>32</sup> Involving Galen, *Method of Medicine*, 10, 448-449K "ἦν δ' ἅπαξ ἐν τι γυμνώσης μέρος... τρόπον ἕτερον ἀνατρήσεως εὐρεῖν ἐγγωρεῖ".

<sup>33</sup> The quotation involves a passage of Galen, *Method of Medicine*, 10, 450K "ὅπόσον δὲ ἐκκόπτειν χρή τοῦ πεπονθότος, ἐφεξῆς σοι δειμῖ. τὸ μὲν ἰσχυρῶς συντριβέν ὅλον ἐξάρειν· εἰ δ' ἀπ' αὐτοῦ τινες ἐπὶ πλέον ἐκτείνοντο ῥωγμαί, καθάπερ ἐνίοτε φαίνεται συμβαῖνον, οὐ χρή ταύταις ἔπεσθαι μέχρι πέρατος, εὖ εἰδότας ὡς οὐδὲν βλάβος ἀκολουθήσει διὰ τοῦτο, τῶν ἄλλων ἀπάντων ὁρθῶς πραχθέντων".

and a lack of professional surgical practitioners in Western Europe until approximately the end of the Early Middle Ages<sup>34</sup>.

The situation began to change with Pope Urban II's call for improved medical treatment for wounded Crusaders<sup>35</sup>, leading to the rise of the Medical School of Salerno<sup>36</sup>. This institution, held in high esteem throughout Western Europe, played a pivotal role in reintroducing the scientific concepts of classical medicine to the region during the 11th century<sup>37</sup>.

Toward the end of the 12th century, physician Rogerius Frugardi of the Medical School of Salerno compiled a four-volume treatise, *Chirurgia* or *Practica Chirurgiae*<sup>38</sup>, rich in traumatology, dedicating the first volume of 44 chapters to matters involving the head, inclusive of the treatment of head trauma<sup>39</sup>. Cranial fractures were treated by perforating adjacent small holes and incising their boundaries with a “saw called *spatomele*”, to remove the bone<sup>40</sup>. This technique was consistent with the classical approach described by Celsus, Heliodorus, Galen, and Paul of Aegina.

Hence, a diachronic review of cranial surgery highlights the evolving prominence of trepans among the array of instruments employed over time. While not as predominant during the Hippocratic era, trepans gained increasing significance alongside the *χοινικίς* (or *modiolus* in Latin) during the Alexandrine-Hellenistic and early Greco-Roman periods, as evidenced by references from Celsus and Heliodorus. Over subsequent centuries, from Galen to Paul of Aegina, the role of trepans became more prominent, particularly as the sawing technique, by the circular denticulate saw, and the use of *χοινικίς* waned in favor. By the time of Rogerius Frugardi, trepans had been firmly established as a pivotal instrument in cranial surgery, underscoring their enduring utility within the medico-surgical tradition.

Rogerius Frugardi's treatise, an important instructional manual on surgical practice, exerted significant influence and was widely disseminated across European medical schools, with Salerno maintaining its status as the most prominent medical institution in Europe until the Renaissance. Impressively, Rogerius Frugardi, continuing the classical medical tradition, recommended the meticulous safeguarding of the dura mater during cranial surgical treatment, a precaution diachronically emphasized in the warnings of Hippocrates (*On Wounds in the Head* xv, 28-35, xxi, 1-10), Celsus (*De Medicina* VIII, 3, 7-8), Heliodorus (*On fissures* XVVI, 11, 12-13), Galen (*Method of Medicine* 10, 448K, 450K), and Paul of Aegina (*Medical Epitome, Surgery*, VI, 90, 5, and *On the Inflamed Dura*, VI, 90, 9).

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<sup>34</sup> Unfortunately, medico-surgical progress stagnated in the west with the fall of the Western Roman Empire. Further, it remains ambivalent if any major cranio-surgical advancements took place in SW Asia, even though Byzantine medico-surgical knowledge was transferred during the 4th c. AD to the Persians (and eventually the Arabs) by the ostracism of the Nestorians from Constantinople (cf. Kshetry *et al.* 2007).

<sup>35</sup> Returning from the first Crusade (1095-1099). On the historical canvas between Rome and Constantinople, the reasons and contexts of the First Crusade (cf. Kaldellis 2017).

<sup>36</sup> The Medical School of Salerno was initially founded by Parmenides the Eleatic (*Παρμενίδης ὁ Ἐλεάτης*), a philosopher active in the late 6th to mid-5th centuries BC, of the Greek colony of Elea (later known as *Velia* during the Roman period). Elea was established by Ionian-Phocaean Greeks on the Tyrrhenian coast, near Salerno. For the historical context of Phocaean explorations in the Tyrrhenian region, see Herodotus, *Historiae*, I, 163 (Nutton 1971).

<sup>37</sup> de Divitiis *et al.* 2004.

<sup>38</sup> Published in 1180 by his student Guido “the young” of Arezzo (Cervellin *et al.* 2020).

<sup>39</sup> De Renzi 1852-59; de Divitiis *et al.* 2004.

<sup>40</sup> de Divitiis *et al.* 2004, 735.

**The renaming progression of Geronimo Fabrizio's and John Woodall's *tre fines* instruments to *trefine*, synonymous with trepan**

The progression of trepan use, from a supplementary tool in the Hippocratic era to a central instrument in cranial fracture treatment, underscores the adaptability of surgeons in refining their methods and preferences within the medico-surgical tradition, spanning from the 5th c. BC to the 12th c. AD. The increasing utility of trepans, particularly as the sawing technique and the use of the *χοινικίς* fell out of favor –as informed by Paul of Aegina– highlights aspects of measured transformation in surgical practices over centuries. In the hands of skilled practitioners, trepans became fundamental instruments for addressing cranial trauma.

Further advancements in cranio-surgical instrumentation, particularly the development of trepans, emerged during the Renaissance, with significant contributions from notable surgeons of the period. French surgeon Ambroise Paré (1510-1590) and Italian surgeon Giovanni Andrea Della Croce (1514-1575) are recognized for their pivotal roles in advancing surgical methods, particularly through early descriptions and illustrations of “trephines”. Additionally, the esteemed Italian surgeon and anatomist Hieronymus Fabricius ab Aquapendente, also known as Geronimo Fabrizio (1533/7-1619), introduced a composite drilling instrument for cranial surgery. Initially designated as *tre fines*, this tripartite instrument, was renamed to *trafine* and ultimately to *trefine*, which by 1656 had become synonymous with *trepan*<sup>41</sup>, derived from the Hippocratic term *τρύπανον*<sup>42</sup>. The instrument featured a three-pronged-arm design, enabling surgeons to use one of the arms for drilling while employing the others to assist with rotation. This design facilitated the precise removal of circular bone sections (disks) with greater accuracy and control<sup>43</sup>, reducing the risk of damaging underlying tissues. Moreover, it laid the groundwork for further refinements in surgical instruments, including the trephine, as developed by French surgeons Jean Louis Petit (1674-1750), Pierre-Joseph Desault (1738-1795), and Pierre-Charles Huguier (1804-1873)<sup>44</sup>.

Additionally, a different version of a composite three-pronged tool was introduced by John Woodall (1570-1643), a prominent English military surgeon. In his 1639 surgical manual<sup>45</sup>, Woodall described the surgical tool he devised, naming it *tres fines*. This instrument was later renamed *trefina* and eventually *trefine*, becoming synonymous with *trepan*. Woodall strongly advocated for the use of the *trefine* in cranial surgery, particularly for young surgeons, and was among the first English surgeons to promote the practice<sup>46</sup>.

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<sup>41</sup> Gross 2009, 9-10.

<sup>42</sup> Borrowed from the Greek noun *τρύπανον*, “drill/borer”, the Latin noun became *trepanum*, and the Middle English trepane, while on the verbs from the Greek *τρύπᾶω*, “to drill”, the Latin verb derived from *trepanum* became *trepanare*, and in the Middle English *trepanen* (the Latin and Middle English terms were quoted from “Trepan” in the Merriam-Webster Dictionary, [www.merriam-webster.com](http://www.merriam-webster.com), last accessed 4-12-2024).

<sup>43</sup> Gross 2009; Syrmos 2006-07.

<sup>44</sup> The life dates of the surgeons were quoted from Encyclopedia Britannica, [www.britannica.com](http://www.britannica.com) (last accessed 4-12-2024).

<sup>45</sup> Woodall 1639, 313.

<sup>46</sup> Gross 1999; cf. Duffin 2021.

### From trepan to “trepanation”: tracing its semantic journey

During the latter part of the 19th century, the term *trepanation*, originating from the word *trepan*, derived from the Greek noun *τρύπανον*, (“borer” or “drill”), underwent semantic extension in the anthropological discourse<sup>47</sup>. It came to encompass the cranial manifestation of any surgical opening in the skull exposing the dura mater, irrespective of the specific procedure, technique, or instruments used. Unfortunately, this shift often occurred in a reductive manner, particularly when comparative references were made to *On Head Wounds*. Such references tend to divert focus from the treatise’s comprehensive sequence of steps for planning, performing, and completing the surgical process –from preoperative preparations to postoperative care.

Further, this etymological shift, while useful as a generic designation for identifying manifestations of cranial surgical intervention in archaeological, bioarchaeological, and osteological studies, has taken undue precedence when compared to the Hippocratic treatise. This shift engenders *ipso facto* a discrepancy by obfuscating the treatise’s educational and mentoring approach. It detracts from the reasoning behind its recommendations, advice, and cautionary warnings, which intended to provide nuanced guidance on selecting specific surgical techniques or their combinations and the appropriate use of instruments in executing the multiple stages of the intervention, from preoperative preparation to post-surgical care.

Moreover, the expanded definition of the term obscures the understanding of those less familiar with the field regarding the specificity of recommendations offered and the precision of the distinct surgical techniques described in the Hippocratic text. This has, in some cases, led to confusion and misconceptions about ancient medico-surgical practices. By conflating the intricate array of recommendations and methods involved in carrying out the procedure under a single, rather reductive term, the historical and technical particularity carefully distinguished in the Hippocratic passages becomes blurred. This challenge is particularly acute for individuals not versed in primary medical historical texts.

Failing to engage with the intricate legacy of Hippocratic surgical practices detracts from their historical significance, reducing archaeologically retrieved cranial surgical manifestations to mere surgical “artifacts”, detached from the sophistication, expertise, and trauma care methods of the ancient surgeons who performed these procedures.

### As an epilogue, addressing critical *scholia* on Hippocrates

The well-documented, diachronic experiential and evidence-based medico-surgical record on the cautionary recommendations to protect the meningeal membrane during the surgical cranial bone treatment may challenge and overturn certain *scholia*<sup>48</sup>. This

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<sup>47</sup> In July 1874, Paul Broca (Broca 1874) presented his work titled *Sur les trépanations préhistoriques* to the Société d'Anthropologie de Paris, subsequently published in the society’s bulletin, examining the practice of surgical trepanation, discussing its historical applications and techniques (cf. Munro 1891).

<sup>48</sup> One example of *scholia* questioning Hippocrates’ capability and expertise in cranial surgery, referred to as “trepanation”, states: “*Hippocrates offered strange recommendations regarding the technique of trepanation. He stated that the bone should be sawed down until only a very thin layer covering the meninges remained. This statement has subsequently prompted suspicion that Hippocrates was not personally acquainted with trepanation (here the authors provide a supportive but biased and uniquely unfounded reference to their postulation by Martin, G., “Was Hippocrates a beginner at trepanning and where did he learn?” J. Clin Neurosci 7 (2000), 500-502); in fact this is not surprising*” (Krivoschapkin et al. 2014).

representative *scholion* claims that the advice, recommendations, and cautionary warnings in *On Head Wounds* (cf. xxi, 1-17, 24-27, 46-55) –specifically, the directive to avoid sawing with the denticulate saw or drilling with the trepan (thus referring to two distinct techniques and instruments) too quickly or deeply into the diploic component through the innermost layer of the endocranial compact table to prevent damage to the meningeal membrane – indicate suspicion that “Hippocrates was not personally acquainted with trepanation”. This assertion fails to consider the implementation of two different surgical techniques and tools, which collapse under the term trepanation. Furthermore, with the benefit of two and a half millennia of medical advancements, it overlooks the deep medico-anatomical knowledge, experience, skill, and intentionality evident in Hippocratic practices.

Further, to provide additional context to the inquiry “Was Hippocrates a beginner at trepanning and where did he learn?” it should be substantiated for the record that by the 7th c. BC, nearly 200 years before Hippocrates’ birth, remarkable cranial trauma treatments were being performed by skilled surgeons in the pre-Classical Hellenic world<sup>49</sup>.

This is exemplified by the meticulously performed surgical intervention at the right parieto-occipital region (fig. 1) of a female individual interred at the Klazomenaeon burial ground in Abdera<sup>50</sup>. The case, involving the locus of the *ἔδρη* and impacting the right component of the unfused, denticulate lambdoidal suture, vividly illustrates the Hippocratic reasoning behind cautionary warnings –ostensibly for novice practitioners– regarding fractures that impact sutures, as outlined in Hippocrates (III, xii), advising to avoid operating directly over the suture itself when employing *πρίωσις* as is required in many of those cases, but rather slightly adjacent to it (III, xii, 41-43). This guidance considers the weakness and thin structure of the unfused dentate edges of sutures, which readily separate at fractured sutural components, contrasted with the stronger and steadier bone boundaries surrounding the sutural locus (III, xii, 16-22)<sup>51</sup>.

The detailed reasoning and explanations provided in Hippocrates (III, xii) prompt the conclusion that an experienced surgeon would have been aware of the danger that thin dentate sutural fragments at the fracture locus could easily diverge and veer toward the meningeal membrane during the rotational movement of the denticulate-serrated saw. This aligns with the recommendations in the Hippocratic treatise, which emphasize the careful and precise execution of tasks during the surgical procedure, particularly the complete removal of diploic components through *πρίωσις* to safely reach the meningeal membrane (III, xxi, 18-51).

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For the record, the closing statement of the abstract of G. Martin’s article states: “*It is suggested that he (Hippocrates) might have learnt trepanning on a brief trip to Marseilles, where the Gauls had already trepanned for 1500 years*”.

<sup>49</sup> cf. Aidonis *et al.* 2021. Regarding representative samples of earlier period cranial surgical operations in the ancient Hellenic world cf. Mountrakis *et al.* 2011; Papagrigorakis *et al.* 2014.

<sup>50</sup> Agelarakis 2006.

<sup>51</sup> Bone surfaces that would favor the implementation of *πρίωσις* to treat the fracture.

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Figure 1. Supero-dorsal cranial view, showing the surgical intervention at the right parieto-occipital region and the involvement of the lambdoid suture (Photo A.P. Agelarakis).