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Hippocratic Hands, Sacred Boundaries: Surgery and its Dilemmas in Ancient Greece

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Rezumat

Mâinile hipocratice, granițe sacre: chirurgia și dilemele ei în Grecia antică

Context: Acest articol oferă o analiză amplă a tehnicilor chirurgicale practicate în Grecia antică, urmărindu-le evoluția din preistorie până în perioadele Clasică, Elenistică şi Bizantină.
Metode: Pe baza izvoarelor literare, arheologice şi anatomice, studiul examinează proceduri precum trepanația, tratamentul fracturilor, reconstrucția nazală şi facială, precum şi primele intervenții la nivel abdominal şi toracic. O atenție deosebită este acordată contribuțiilor lui Hipocrate, Galen şi Paul din Aegina, ale căror abordări sistematice privind traumatismele, îngrijirea rănilor şi tehnicile operatorii au stat la baza tradițiilor chirurgicale ulterioare. Studiul evidențiază, de asemenea, utilizarea instrumentarului specializat, a tratamentelor farmacologice şi a considerațiilor etice ancorate în gândirea mitologică şi filozofică.
Rezultate: Prin prezentarea complexității ştiințifice şi a influenței durabile a practicilor chirurgicale din Grecia antică, această lucrare subliniază rolul lor esențial în dezvoltarea medicinei occidentale.
Concluzii: Chirurgia din perioada Greciei Antice se conturează ca o intersecție complexă între îndemânare empirică, reflecție etică şi semnificație culturală - o practică modelată atât de reținerea filozofică, cât şi de ingeniozitatea tehnică.

Cuvinte-cheie: chirurgia Greciei antice, medicina hipocratică, trepanație, Paul din Aegina, instrumentar chirurgical, medicina bizantină, istoria chirurgiei

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Abstract

Background: This article offers a comprehensive exploration of surgical techniques practiced in ancient Greece, tracing their development from prehistoric times through the Classical, Hellenistic, and Byzantine periods.
Methods: Drawing on literary, archaeological, and anatomical evidence, this examination explores procedures such as trepanation, fracture management, nasal and facial reconstruction, and early interventions in the abdominal and thoracic regions. Particular attention is given to the contributions of Hippocrates, Galen, and Paul of Aegina, whose systematic approaches to trauma, wound care, and operative techniques laid the foundation for later surgical traditions. The study also highlights the use of specialized instruments, pharmacological treatments, and ethical considerations rooted in mythological and philosophical thought.
Results: By highlighting the scientific sophistication and enduring influence of ancient Greek surgical practices, this work underscores their pivotal role in the development of Western medicine.
Conclusions: Ancient Greek surgery stands as a complex intersection of empirical skill, ethical reflection, and cultural meaning - a practice shaped as much by philosophical restraint as by technical ingenuity.

Keywords: ancient Greek surgery, Hippocratic medicine, trepanation, Paul of Aegina, surgical instruments, Byzantine medicine, history of surgery

Introduction

To describe surgery in ancient Greece as "just" medicine is to oversimplify a profoundly complex cultural and philosophical act. The incision of the human body - performed in a world where divine oversight was omnipresent - was not merely a technical maneuver, but a bold metaphysical gesture, often perceived as a challenge to cosmic order. While Hippocratic writings portray the human frame as a system of intelligible parts, open to empirical analysis and rational intervention, the legacy of taboo and sacred boundary persisted at the surgical table (1-7).

Every incision embodied a paradox: it was both an assertion of human reason and a confrontation with the unknown. Surgery in this context was not only about control and cure, but also about navigating the limits of propriety and confronting the charge of hubris - the overstepping of mortal boundaries into realms guarded by the gods. Ancient Greek physicians operated in a conceptual space where the body was simultaneously a physical system and a vessel of sacred mystery (2,3).

This duality is woven through the surviving medical literature. The treatises of Hippocrates and Galen, along with fragmentary texts from lesser-known practitioners, are rich in technical detail - detailing instruments, procedures, and case reports - yet they are also haunted by ethical unease and philosophical caution. Between the lines lies a silent query: is it right to open the body? Can the hand of the physician be trusted with what lies beneath the skin when life, death, and the sacred are at stake (4,5)?

This article explores the evolution of surgical practice in ancient Greece as a dynamic interplay between empirical skill and metaphysical apprehension. It traces how surgical interventions were shaped not only by anatomical knowledge and therapeutic aims but also by cultural anxieties, moral deliberations, and existential awe. Every act of surgery in antiquity, this study suggests, was not only an attempt to heal - but also a moment of confrontation with the fragile boundary between human power and divine order.

Materials and Methods

This study is based on a qualitative historical review of primary and secondary sources related to surgical techniques in ancient Greece. The investigation was designed to encompass a broad chronological spectrum, from prehistoric Aegean practices to late antiquity and the Byzantine period, with a focus on techniques, instruments, therapeutic philosophies, and cultural contexts.

Literature Search Strategy

A comprehensive literature search was conducted using PubMed, Scopus, JSTOR, and Google Scholar. Additional material was sourced from classical texts (e.g., the Hippocratic Corpus, Galenic writings, scripts written by Paul of Aegina) in translation, as well as from archaeological and museum reports, historical monographs, and peer-reviewed journals in medical history, paleopathology, and classical studies. Reference lists from retrieved publications were also examined to identify further relevant sources.

Inclusion Criteria

- Scholarly articles, monographs, or chapters focusing specifically on surgical techniques, trauma management, anatomical knowledge, or surgical instrumentation in ancient Greece or the broader Greco-Roman world.
- Archaeological and osteological studies presenting physical evidence of surgery (e.g., trepanations, skeletal trauma repair).
- Translations and scholarly analyses of relevant ancient medical texts, including the Hippocratic Corpus, Galen, and Paul of Aegina.
- Peer-reviewed studies published in English, German, French, or Greek.

Exclusion Criteria

- Modern surgical studies without historical analysis or relevance to ancient techniques.
- Non-scholarly material lacking citations, such as popular media articles or speculative historical fiction.
- Articles focusing solely on philosophical or metaphysical aspects of ancient medicine without specific reference to surgical practice or procedures.
- Duplicated studies or reviews without added primary analysis or interpretation.

Data Extraction and Synthesis

Relevant data were extracted regarding the types of procedures described or evidenced, tools used, anatomical knowledge reflected, patient outcomes (where available), and the socio-religious or ethical context of surgical practice. Findings were categorized thematically (e.g., cranial surgery, trauma treatment, facial reconstruction) and synthesized to highlight patterns of continuity, innovation, and cultural interpretation within ancient Greek surgery.

The Cultural Context of Ancient Greek Surgery

To understand ancient Greek surgery is to confront a dense web of cultural, philosophical, and religious anxieties surrounding the body. Surgery was never a purely technical endeavor; it represented a negotiation between necessity and taboo, deeply embedded in the civic, religious, and intellectual fabric of society (6,7).

Evidence from the Bronze Age Aegean, particularly in the Minoan and Mycenaean civilizations, points to surprisingly advanced surgical activity as early as 3,500-4,000 years ago. Archaeological findings reveal the practice of cranial trepanation - likely performed to relieve trauma or disease - with signs of long-term survival, indicating successful intervention. Bronze cutting and piercing tools, recovered from tombs and settlements,suggest a high level of metallurgical skill and their potential use in therapeutic contexts. Additionally, the management of war-related injuries implies the existence of organized and empirical healing practices long before the emergence of classical Greek medicine (8).

In the classical polis, healing was a communal act, conducted under the gaze of family, society, and the gods. The Asclepieia - temples dedicated to Asclepios, the deity of medicine - served not only as centers of healing but also as ritualized spaces where empirical treatment, religious devotion, and personal hope converged (9-11). Patients sought cures through incubation rituals, dream interpretations, and sometimes surgical intervention, in a therapeutic system where the divine and the medical were closely entwined. To ground this exploration in the physical spaces where healing and surgical practice were first ritualized and refined, *Fig. 1* illustrates some of the most prominent Asclepieia of the ancient Greek world - temples that served not only as centers of religious devotion but as early incubators of medical and surgical thought.

Greek thought treated the human body with both analytical curiosity and religious caution. There was a persistent desire to explore, dissect, and understand human anatomy - to theorize illness and develop interventions - yet this was balanced by fear of violating sacred boundaries. Surgical acts, especially invasive ones, were often preceded by purification rituals, sacrifices, and prayers, reflecting the lingering belief that bodily integrity was under divine jurisdiction (1,4).

The physician occupied a complex and precarious social role. Far from being a mere technician, the healer was subject to intense scrutiny. A successful operation could elevate a physician to public esteem; a failure could lead to social disgrace or legal consequences. The Hippocratic Oath was not simply an ethical declaration - it functioned as a moral and practical code for navigating the high stakes of surgical practice (12).

This moral tension permeates ancient medical texts. Hippocratic treatises emphasize prudence and caution, advising surgery only when absolutely

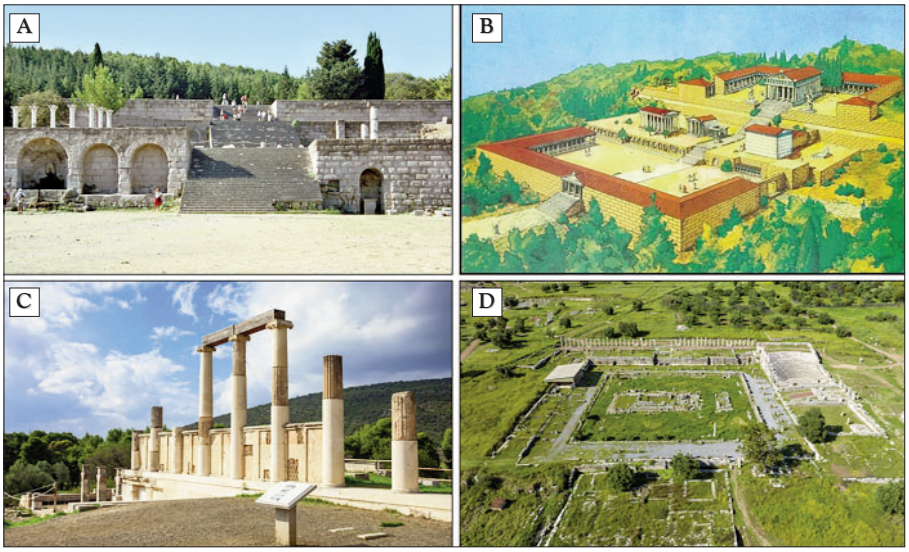

Figure 1. Ancient Asclepieia: Centers of Healing in Classical Greece.Visual representations of prominent sanctuaries dedicated to Asclepios, the god of healing, which served as major centers of medical practice and surgical innovation in the ancient Greek world. **(A)** Modern view of the archaeological site of the Asclepieion of Kos, one of the most renowned healing temples and a key center for Hippocratic medicine. **(B)** Artistic reconstruction of the ancient Sanctuary of Asclepios in Kos, illustrating the architectural layout and ceremonial pathways used for ritual and therapeutic purposes. **(C)** Ruins of the Sanctuary of Asclepios in Epidaurus, celebrated for its amphitheater, tholos, and historical reputation as the most significant healing sanctuary in ancient Greece. **(D)** Remains of the Sanctuary of Asclepios in ancient Messene, highlighting the integration of religious devotion and medical care in Hellenistic healing traditions.

necessary and warning against interventions that could cause irreparable harm (5). Yet within the same texts, there is evident admiration for technical skill and anatomical precision - especially in descriptions of joint manipulation, wound care, and trauma management (13).

War played a pivotal role in shaping surgical innovation. From Homeric duels to interpolis conflicts, the battlefield served as both crucible and clinic. Greek surgeons - often attached to military campaigns - were forced to adapt, improvise, and innovate. The treatment of arrow wounds, compound fractures, and internal injuries became part of a growing surgical repertoire. Medical texts document both successes and failures, with meticulous descriptions of instruments, bandaging techniques, and step-by-step procedural guidance for tasks such as spear extraction or joint relocation (14,15).

Within the urban context, surgical care continued to evolve. Afflictions such as dental abscesses, gangrene, and childbirth complications were approached with a blend of empirical treatment and cautious deliberation. Techniques like cauterization, splinting, surgical excision, and wound management were deployed judiciously, often guided by a sense of when human intervention was appropriate - or when to defer to fate or divine will (16).

The role of religious belief remained central. In the Asclepieia, healing rituals often involved dream incubation and symbolic acts, interpreted by priests or physicians. Sometimes, surgery itself was part of the sacred experience, with ritual and technique merging into a single therapeutic act (9). Nonetheless, the conflict between empirical observation and religious taboo persisted, especially regarding dissection and anatomical investigation. While mostly forbidden, dissection was occasionally practiced in secrecy, particularly in Alexandria and select centers of learning (7).

A culminating figure in the surgical tradition was Paul of Aegina (ca. 625-690 AD), whose Epitome of Medicine, especially Book VI, compiled centuries of surgical knowledge while introducing novel practices. His work detailed procedures such as tonsillectomy, bladder lithotomy, abdominal incision, hernia repair, tracheotomy, and cauterization. Paul demonstrated remarkable clinical range, blending Hippocratic restraint with Galenic theory and his own operative insight (17). His systematic approach and technical clarity influenced not only Byzantine and Islamic medicine - shaping the work of Rhazes, Avicenna, and Albucasis - but also

transmitted Greek surgical principles to medieval and early modern Europe (18).

What emerges from this cultural and historical panorama is not a linear progression, but a dynamic process of negotiation. Ancient Greek surgery was always an act at the edge - between reason and belief, between individual body and communal order, between hope for recovery and fear of transgression. It was a practice forged in the crucible of necessity, tempered by awe, and continually shaped by the shifting boundaries of what could - and should - be done to the human body.

Surgical Instruments and Methods of Ancient Greek Surgery

The archaeological museums of the Mediterranean make one fact unmistakably clear: the ancient Greeks approached surgical instrumentation with deliberate precision and technical seriousness. Examining collections of scalpels, forceps, hooks, and probes - ranging from utilitarian to astonishingly complex - reveals that medicine in antiquity was as much a metallurgical craft as it was a healing art (15,19). Materials were selected with care: bronze and iron dominated for their durability and cutting edge, while silver was occasionally reserved for delicate procedures or ceremonial use. These instruments reflect not only technical advancement but also an underlying reverence for the act of bodily intervention itself (20). To visually complement the textual descriptions of surgical tools and highlight the level of craftsmanship and anatomical insight achieved by ancient Greek physicians, *Fig. 2* presents reconstructions of Greco-Roman instruments based on archaeological findings and Hippocratic sources.

The evolution of ancient surgical tools illustrates a dynamic blend of empirical observation, anatomical theory, and craftsmanship. From flint blades used in early trepanation to the increasingly specialized bronze implements of classical Greece and Rome - such as cannulae, hooks, and knives - Greek surgical practice shows a clear trend toward anatomical specificity and therapeutic efficiency. The Hippocratic tradition, with its emphasis on precision, directly influenced the design of instruments like the amphismela (a double-edged knife) and klyster(a form of enema syringe), laying the foundation for later Roman innovations (21).

As noted in the discussion of ancient surgical knives, early Greek surgeons transitioned from primitive stone tools to refined bronze instruments, culminating in the use of specialized knives like the amphismela. These were crafted for both superficial incisions and deeper, more complex interventions. The classical surgical toolkit was not only a testament to metallurgical skill but also to a growing sophistication in technique and understanding of anatomy (22).

The Hippocratic treatises and Galenic writings offer detailed inventories of surgical tools: from narrow-bladed scalpels (machairia) and broad knives for major incisions, to spatula-shaped probes, bone levers, wound retractors, and tooth forceps. Their lists include arrow extractors, suturing needles, and even bone saws - indicating a highly organized surgical practice. Each tool was designed with a specific function in mind, suggesting a continual process of refinement based on clinical experience and patient outcomes (5,13).

Figure 2. Reconstructed Surgical Instruments from the Ancient Greek World. This figure illustrates the sophistication and specialization of surgical tools used in classical antiquity, reflecting the empirical craftsmanship of Greek physicians and their evolving understanding of human anatomy. **(A)** Reproductions of Greco-Roman medical instruments from the Milwaukee Public Museum (MPM) Collection, showcasing scalpels, probes, forceps, and cautery devices, representative of the equipment described in ancient surgical texts (Courtesy: Milwaukee Public Museum).
(B) Reconstructions of surgical instruments dating to the 5th century BCE, based on textual descriptions found in the Hippocratic Corpus. These replicas - including knives, hooks, and cannulae - are exhibited at the Thessaloniki Technology Museum and exemplify early technical precision in operative care.
(Courtesy: Thessaloniki Technology Museum)

Greek surgeons paid close attention not only to their tools, but also to technique. Texts instructed physicians to match the instrument to the procedure and to master its handling: the grip, angle, incision depth, and order of steps were meticulously described. Cautery irons, heated in flames and applied to wounds, served to control bleeding and seal vessels - a precursor to hemostatic practices (14,19, 23).

An important dimension of ancient Greek instrumentation lies in the early development of tools for internal procedures. Analyses of airway-related instruments reveal the use of bronze or lead cannulae, known as klysters, for draining fluids or administering medication into the nose, rectum, or uterus. Hooks and probes - like the agkistron—were employed for lifting tissues, retracting vessels, and examining wounds, demonstrating a surprising level of procedural dexterity and surgical ambition (24).

Despite their era, ancient Greek physicians paid considerable attention to hygiene. While rudimentary by modern standards, instruments were often cleaned with boiling water, wine, vinegar, or passed through flame. Medical texts occasionally warn of "corruption of the wound," indicating an early, intuitive recognition of infection control principles (25).

Methods of anesthesia and restraint also reflected creative adaptation. Patients were often held down by assistants, given leather to bite, or partially sedated with herbal compounds containing opium, mandrake, or wine. Pain management remained inconsistent, and accounts of patients crying out, fainting, or enduring procedures in silence reflect the brutal reality of premodern surgery (16,26).

Perhaps most impressive was the fusion of technical rigor with ethical caution. Surgeons were trained to adapt, innovate, and - importantly - recognize their limits. The Hippocratic texts caution against overreach, urging restraint and discouraging unnecessary interventions that might turn a manageable injury into a fatal mistake. "Leave well enough alone," one passage advises - an ancient appeal for clinical humility (5).

Ultimately, the surgical instruments and methods of ancient Greece reflect more than technical progress. They reveal a complex and evolving relationship to the human body - marked by bold experimentation, hard-earned skill, and a sobering awareness of medicine's risks. Each tool tells a story not just of healing, but also of the intimate negotiations between knowledge, suffering, and the limits of human control.

Surgical Techniques and Achievements

The true test of Greek surgical ingenuity was not in the cold gleam of instruments, but in the techniques developed at the crossroads of science, experience, and crisis. Each treatise, each fragmentary case, is a window into a world where the line between life and death was sometimes measured in millimeters - or in moments of unrepeatable nerve (7,13). To better understand the historical evolution of surgical innovation in ancient Greece, *Fig. 3* presents a chronological timeline of key medical figures and milestones - providing essential context for the techniques and achievements discussed in the sections that follow.

Orthopaedic Mastery and Trauma Surgery

The true test of Greek surgical ingenuity did not lie solely in the precision of their instruments, but in the techniques honed at the confluence of empirical observation, anatomical understanding, and clinical necessity. Each treatise, each preserved case report, opens a window into a medical world where the boundary between survival and mortality was measured in fractions - of seconds, of millimeters, of judgment (7,13).

Among the most consistently practiced and developed surgical domains in ancient Greece was the treatment of skeletal injuries. The roots of Greek orthopaedics extend back to Homeric texts, where trauma and injury from battle are vividly described. In the classical period, physicians such as Hippocrates and Galen systematized approaches to bone-setting, joint relocation, wound care, and immobilization - laying the intellectual and procedural foundation for the emergence of orthopaedics as a formal discipline in both antiquity and, ultimately, in modern Greece (27).

The Hippocratic writings On Joints and On Fractures offer methodical accounts of reduction techniques for dislocations and fractures. These procedures involved precise traction, careful manipulation, and stabilization with linen bandages and splints made of bark or wood. The texts emphasize tactile sensitivity - listening for the subtle "click" as a joint returned to position - and caution in every motion. For more complex cases, traction devices using weights and pulleys were employed, attesting to a surprisingly

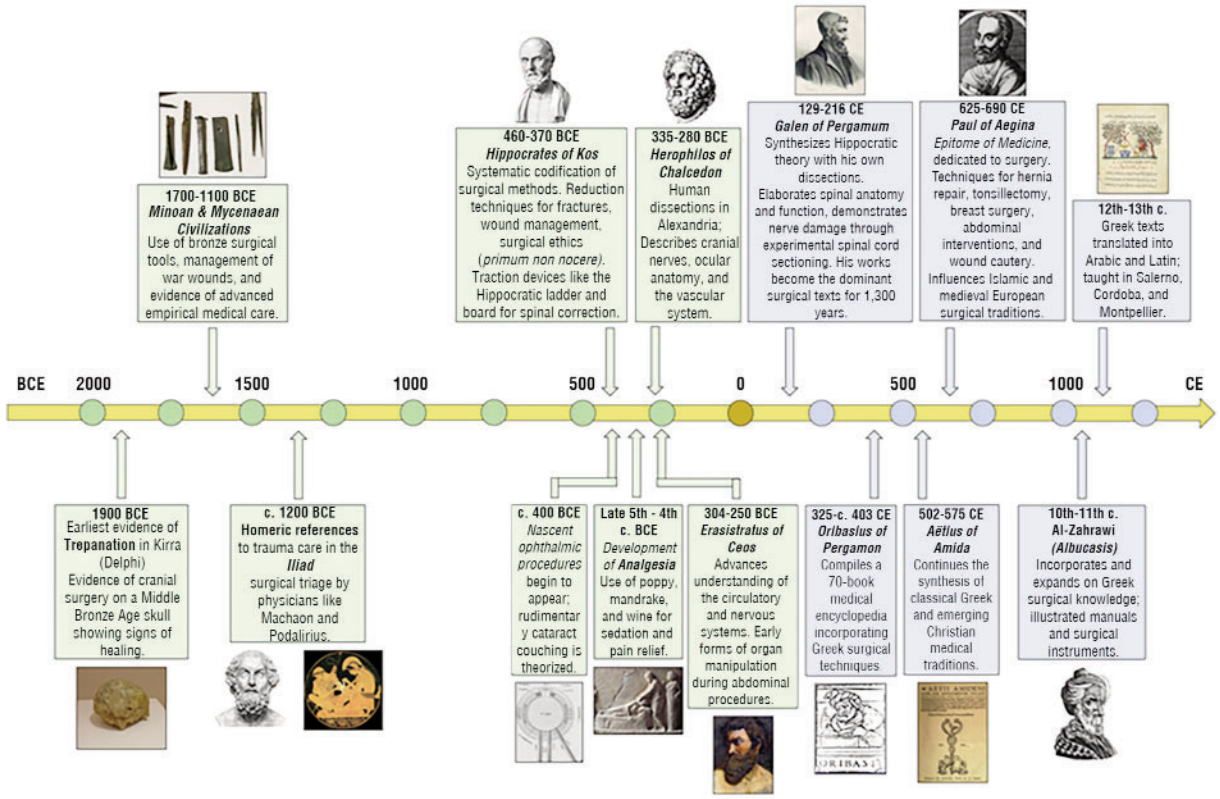

Figure 3. Timeline of Ancient Greek Surgical Development. This timeline presents key milestones in the evolution of ancient Greek surgery, from early cranial trepanation (c. 1900 BCE) to the Byzantine era. It highlights major figures such as Hippocrates, Herophilos, Erasistratus, Galen, and Paul of Aegina, as well as the later transmission and transformation of Greek surgical knowledge through Islamic scholars and the Renaissance.

advanced understanding of biomechanical leverage (5,23).

Hippocrates' surgical acumen is further evidenced in the detailed trauma case reports found in the Epidemics. As analyzed by Golder, these include 26 documented cases encompassing musculoskeletal conditions such as arthritis, tendinopathies, scoliosis, and ten cranial fractures - four of which were treated using trepanation. These reports demonstrate careful diagnostic practices based on inspection and palpation, as well as a nuanced understanding of complications like tetanus, diagnosed by observing opisthotonus. The repeated application of trepanation, described with clinical precision, reflects a medical culture both theoretically grounded and technically adept (10,28).

This corpus of work-particularly On Fractures, On Joints, and Mochlikon - is recognized as foundational in the development of traumatology and orthopaedics. The Hippocratic authors explore the dynamics of bone healing, outline signs of gangrene and infection, and offer practical guidance for spinal conditions, including hyperkyphosis and scoliosis. These texts mark Hippocrates as a true pioneer whose influence endured across centuries, echoing through surgical literature and practice into the modern era (29).

Centuries later, the Byzantine physician Paul of Aegina (c. 625-690 AD) expanded the scope of orthopaedic intervention. In his Medical Compendium, he provided the earliest known detailed description of surgical treatment for congenital anomalies such as polydactyly. Classifying supernumerary digits based on their skeletal and soft-tissue features, he offered techniques for their removal and reconstruction. This represents one of the first documented efforts in reconstructive orthopaedic surgery, signaling a shift toward addressing not only traumatic but also congenital and cosmetic conditions in Greek surgical thought (17,18,30).

Foundations of Spinal Surgery and Anatomy

Hippocrates (5th - 4th century BCE) stands as a foundational figure in the history of spinal surgery, earning recognition as the first to systematically study and treat spinal disorders. His writings present remarkably detailed accounts of vertebral anatomy, spinal curvature, ligaments, tendons, and vascular supply. He identified and described a wide array of spinal conditions, including tuberculous spondylitis, post-traumatic kyphosis, scoliosis, vertebral dislocations, concussions, and fractures. In response to vertebral misalignment, Hippocrates developed innovative therapeutic devices such as the Hippocratic ladder and the Hippocratic board-mechanical apparatuses designed to apply traction and facilitate vertebral realignment. These tools represent some of the earliest documented attempts at spinal reduction and can be seen as forerunners of modern orthopaedic techniques. His integrated approach - merging anatomical observation with therapeutic engineering - firmly establishes his legacy as the first true spinal surgeon in recorded history (31,32).

Building on this tradition, Galen of Pergamum (2nd century CE) expanded and systematized the anatomical understanding of the spine. Relying heavily on animal dissection and vivisection, Galen offered precise descriptions of the vertebral column, spinal cord, and associated nerve pathways. His investigations into spinal trauma and disease, including tuberculosis of the spine, went further to explore the functional implications of spinal cord injury. In a groundbreaking series of experiments, he demonstrated that transections at different spinal levels produced specific neurological deficits - an insight that foreshadowed modern neurology. Galen's comprehensive synthesis of spinal anatomy and pathology dominated medical thought for over a millennium, serving as a cornerstone for both medieval and early modern neurosurgical knowledge (33-34).

Trepanation: Opening the Skull

Among the boldest surgical techniques practiced in antiquity was trepanation - the deliberate opening of the skull to relieve intracranial pressure or extract bone fragments after trauma. Archaeological finds attest to the antiquity and sophistication of the practice: a Middle Bronze Age skull from Kirra, near Delphi (c. 1900 BCE), revealed a precisely shaped hole in the right parietal bone - measuring about 8 × 7.5 mm - likely produced by a metal tool. Signs of bone regeneration around the trepanation site confirm the patient's survival, making this one of the earliest documented examples of neurosurgical intervention in the Western world. Additional evidence from Thessaly shows healed cranial openings, suggesting a well-established practice of cranial surgery long before the rise of classical Greek medicine (13,35).

The procedure was approached with great care and anatomical awareness. Hippocratic and Galenic texts describe trepanation as a precise, calculated act: surgeons were instructed to avoid major vessels and underlying membranes by scraping gradually or cutting in controlled circles. Such techniques were not mystical acts but rational procedures grounded in empirical observation and anatomical logic (36). Within the Asclepieia, trepanation became one of the earliest systematized forms of cranial surgery. These settings provided not only the technical skill but also a structured environment for postoperative care, likely contributing to high survival rates (6).

Skeletal remains from the ancient Greek colony of Akanthos (5th - 1st century BCE) illustrate the prevalence and variation of this procedure. Seven trepanations across four skulls - executed via both scraping and drilling - demonstrated a survival rate of roughly 63%. Long-term healing in some individuals and short-term survival in others reflect the risks involved and the practitioners' evolving skillset. The procedures appear to follow, yet occasionally diverge from, Hippocratic standards, indicating both respect for tradition and practical adaptability (37).

A trepanned skull from Chios offers further confirmation: a clean, beveled burr hole adjacent to a linear fracture indicates the procedure was used to treat acute cranial trauma. Evidence of bone healing supports the notion that trepanation was not only anatomically informed but often successful. This case aligns precisely with Hippocratic instructions from On Injuries of the Head, highlighting the deliberate, empirical character of ancient Greek neurosurgery (38).

Nasal Surgery and Facial Fractures

The treatment of nasal and facial injuries in ancient Greece reflects a remarkable blend of anatomical insight, surgical precision, and pragmatic methodology. Hippocratic texts such as Mochlikon and On Joints classify nasal trauma from soft-tissue contusions to complex fractures and prescribe systematic therapeutic approaches. These included

the application of poultices - often made from wheat flour paste - minimal yet supportive bandaging, and conservative manipulation of displaced bones. In more severe cases, physicians performed bone reshaping through manual pressure or surgical correction, revealing both detailed anatomical knowledge and a careful understanding of functional reconstruction (39,40).

This foundational approach laid the groundwork for the evolution of nasal surgery throughout the Mediterranean. In De Articulationibus, Hippocrates emphasized closed reduction techniques, while Galen expanded and preserved these practices in his anatomical treatises. Byzantine scholars such as Oribasius and Aëtius later integrated Greek knowledge with Middle Eastern medical insights, enriching a cross-cultural surgical tradition. These cumulative contributions formed the basis of Western rhinoplasty, extending into the medical curricula of medieval European schools (41).

Beyond nasal trauma, facial fractures were also managed with notable sophistication. Mandibular breaks, for instance, were stabilized using gold wire and rudimentary splints - methods conceptually consistent with modern fixation techniques. Nasal injuries were treated with internal packing, structural support, and external pressure dressings, often determined by whether the cartilage, bone, or both were affected. These protocols demonstrate that by the 5th century BCE, Greek surgeons possessed a nuanced understanding of maxillofacial trauma and its management (40,42).

Paul of Aegina, writing in the 7th century CE, offered the most comprehensive account of nasal fracture treatment in antiquity. He classified injuries by their severity and location, recommended closed realignment techniques, and described the use of feather straws, cotton plugs, and wedge-shaped dressings to maintain nasal structure. His detailed descriptions and methodical approach underscore the continuity between ancient practices and modern otolaryngologic techniques, and his influence extended well into Byzantine and later European medicine (17,43).

Battlefield Medicine and Amputation

Trauma care in ancient Greece emerged from the brutal realities of warfare and daily accidents, fostering a medical tradition grounded in empirical observation and practical necessity. Physicians treated a wide array of injuries - fractures, dislocations, penetrating wounds, and cranial trauma - through techniques such as wound debridement, splinting, traction, and reduction of dislocations. These methods reflected a nuanced understanding of human anatomy and a rational approach to healing that formed the foundation of many principles still present in modern surgical practice (44).

A significant portion of surgical innovation came directly from battlefield experiences. Surgeons were called upon to manage arrow and spear wounds, crushed limbs, and severe blunt trauma under extreme conditions. Medical texts and commentaries reveal both technical details and the psychological burdens of such interventions. Limb amputations, while rare and always a last resort, are mentioned in passing - usually in cases of irreversible damage. The tone in some treatises reveals a deep awareness of the emotional toll surgery took on both patients and practitioners, balancing hope and despair in moments of crisis (4,14).

The Iliad offers a vivid literary account of early trauma care, with 21 specific cases detailing treatments such as arrow extraction, cleaning wounds with seawater, and finger bandaging. The estimated mortality rate for nonfatal wounds in these accounts is surprisingly low (≈5 %), suggesting an organized system of medical triage. Arrow injuries were the most frequent (43 %), commonly targeting the upper limbs, while thoracic, head, and neck wounds tended to be fatal and often went untreated. Importantly, the Iliad also mentions specialized battlefield physicians - such as Machaon and Podaleirios - who performed surgeries and administered medicines, pointing to an established role for medical professionals in combat settings (45).

Homeric descriptions of thoracic injuries further underscore the anatomical precision of ancient observers. A total of 54 chest wounds are detailed, mostly caused by spears (63 %), followed by stones, arrows, and swords. These are classified into mild, moderate, and severe injuries - with about 70 % resulting in death. The narratives distinguish between aggressors and victims, document exact wound locations, and even describe treatment procedures, offering an early form of combat surgery documentation. The care provided by war physicians within these epic tales illustrates a sophisticated understanding of trauma and early surgical care within a mytho-logized yet medically grounded framework (46).

Abdominal Surgery

Although the Hippocratic texts lack formal surgical treatises dedicated solely to abdominal operations, they contain scattered yet compelling evidence of early interventions in this anatomical region. These references suggest a practical knowledge of anesthesia, antisepsis, and surgical ligation (apolinosis), as well as a nuanced understanding of the risks associated with penetrating injuries and intra-abdominal infections. One notable example involves the drainage of empyema through a combination of tracheal intubation and thoracotomy - a technique that bridges both thoracic and abdominal domains and reflects a surprisingly integrated approach to internal pathology. Hippocratic physicians often navigated between conservative care and emergency operative techniques, indicating a pragmatic balance between theoretical restraint and surgical necessity (47).

Gastrorrhaphy, the surgical repair of stomach wounds, was practiced in antiquity with notable precision and care. Ancient medical knowledge included techniques for suturing the stomach wall, managing abdominal injuries, and providing post-operative care. Celsusdescribed one technique for performing gastrorrhaphy, whereas Galen outlined two distinct approaches. Despite these variations, all three methods share common procedural steps: repositioning of the prolapsed internal organs, thorough cleansing of the wound, and suturing. The key differences lie in the suturing technique. Celsus recommended layered stitching, while Galen's first approach involved joining the peritoneum to the abdominal wall. In his second technique, he advised suturing like tissues together - peritoneum to peritoneum and abdominal wall to abdominal wall. These practices demonstrate a sophisticated understanding of human anatomy and trauma treatment, revealing that effective surgical intervention was possible long before modern medicine (48).

In the 4th century BC, an innovative approach to treating small bowel obstruction was introduced by Praxagoras of Cos. This involved the creation of a diverting enterocutaneous fistula. This method involved surgically opening the abdominal wall and connecting it to the intestine, allowing intestinal contents to exit the body and relieving the obstruction. The technique reflects a deep understanding of both gastrointestinal function and surgical intervention in early medicine. It demonstrates that, even in antiquity, physicians sought creative and practical solutions to life-threatening conditions using the anatomical and physiological knowledge available to them (49).

In a more enigmatic case, Erasistratus (3rd century BCE) is credited with a procedure described by the Latin term ventremdeducere, literally translated as "to draw down the belly." This phrase has puzzled scholars for decades. It may denote the deliberate surgical repositioning or even partial exteriorization of abdominal organs - possibly the intestines - during interventions such as hernia repair or to manage abdominal trauma. Fischer's linguistic and philological analysis probes whether the phrase reflects a literal manipulation of viscera or functions as a metaphor for a broader surgical technique. Though definitive interpretation remains elusive, the terminology suggests that Hellenistic surgeons like Erasistratus engaged in complex abdominal procedures with both anatomical insight and bold innovation (50).

Together, these accounts reveal that abdominal surgery in ancient Greece was not incidental or haphazard. It was approached with caution, method, and a growing confidence in the physician's ability to intervene below the diaphragm - areas once thought too dangerous or sacred to touch.

Wound Management, Debridement, and Cautery

Ancient Greek surgeons demonstrated notable sophistication in the care of wounds - treating not only the visible lesion but also anticipating the unseen risks of infection and systemic decline. Their methods combined empirical knowledge with practical adaptation: wounds were irrigated using water, wine, or vinegar, while foreign objects were extracted with specialized forceps or fine hooks. In cases of persistent bleeding, cautery irons were heated and applied to seal vessels - a technique both lifesaving and harrowing, often leaving indelible physical and social marks (14,15).

Suturing techniques varied according to wound type and location. Linen thread was commonly used, and closure was executed with a blend of pragmatic craftsmanship and ritual care. The act of sealing a wound was both mechanical and symbolic - an assertion of control over the body's integrity in a world where healing was still entwined with divine favor and community judgment. The Greeks were among the first to systematically distinguish between fresh and chronic (non-healing) wounds. Their observational acumen enabled them to identify the four cardinal signs of inflammation - rubor, tumor, calor, and

dolor (redness, swelling, heat, and pain) - centuries before these concepts were formalized in Roman and modern medicine. Treatment strategies included wound debridement, the application of herbal or animal-based salves, and rudimentary antiseptic practices. Dressings evolved over time and could include materials such as lint, honey, or animal fats, designed to both protect and promote granulation. While the Romans would later elaborate on antiseptic dressings, the Greeks laid the conceptual and technical groundwork. Their approach - emphasizing cleanliness, inflammation control, moisture balance, and mechanical protection - stands as a surprisingly modern foundation for wound care practices (51,52).

Dental, Ophthalmic, and Minor Procedures

Ancient Greek physicians did not overlook the smaller, localized ailments that caused daily suffering. From dental abscesses to ophthalmic disorders, their writings reveal a pragmatic yet surprisingly sophisticated engagement with conditions that modern medicine might classify as minor, though for ancient patients they were anything but.

Dental care, though limited by the absence of anesthesia or antiseptic protocols, was nonetheless practiced with functional efficiency. Infected teeth were extracted using forceps; carious lesions were sometimes drilled with manual instruments and packed with linen or herbal pastes to reduce pain and decay. Hippocratic and later authors described the management of gingivitis, jaw dislocations, and mandibular fractures, often applying poultices and immobilization techniques that resemble the early roots of oral surgery (1,13,53).

Ophthalmology, however, was perhaps the most symbolically charged field in ancient medicine. The eyes—considered both windows to the soul and sensitive anatomical structures - were treated with exceptional care and ritual. Hippocratic texts contain references to ocular inflammation, cataracts, and external injuries, and propose treatments ranging from herbal poultices and fumigations to cautery of the eyelid margins for chronic blepharitis (54).

Most remarkable is the documentation of cataract surgery, an operation that was both feared and revered. Ancient Greek and Roman physicians occasionally performed a procedure akin to couching, where a sharp needle or lancet was used to displace the opaque lens into the vitreous chamber, thereby restoring partial sight. Though risky and often only temporarily successful, the operation reveals a significant anatomical understanding and a willingness to intervene surgically in the eye - one of the body's most delicate and symbolically sacred organs (54,55).

Healing temples such as the Asclepieia also played a crucial role in ophthalmic care. Patients would undergo ritual purification, make votive offerings, and participate in incubation - a form of sacred sleep believed to bring divine dreams or healing visions. Inscriptions and archaeological evidence suggest that some patients experienced relief or perceived cures from eye ailments, which were then recorded as miraculous recoveries. While these events likely combined placebo effect, natural remission, and basic therapeutic care, they also show the intersection of empirical medicine and spiritual practice within Greek ophthalmology (56).

Minor surgical interventions were common in this pragmatic framework of care. Cysts were incised, abscesses drained, hemorrhoids ligated or cauterized, and anal fistulas treated with surgical knives and probes. The use of simple anesthetic agents such as mandrake, poppy extract, or henbane helped dull pain during short procedures, though much depended on patient fortitude and practitioner speed (13).

These practices, while not as dramatic as trepanation or abdominal surgery, are just as revealing. They illustrate a medical worldview rooted in attentive observation, empirical testing, and a readiness to intervene even in sensitive areas of the body - whether the tooth, the eyelid, or the sacred lens of the eye.

Tracheostomy and Airway Management

Ancient Greek physicians were pioneers in developing techniques for airway management and early thoracic surgery. Although early wellness traditions favored non-invasive approaches, later practitioners refined high-risk procedures such as tracheotomy to secure the airway in life-threatening obstruction. These interventions were based on detailed anatomical insights - especially regarding airway structures - and emergency medical doctrine that extended to battlefield care. While tracheotomy remained rare due to its inherent dangers, archaeological clues and references to experimental methods - such as early ventilation tools and strategic airway incisions - reflect a sophisticated, evolving understanding of respiratory surgery that influenced later

Hellenistic, Roman, and medieval medical traditions (57,58).

Case Studies and the Drama of Success and Failure

Scattered throughout ancient Greek medical texts are clinical vignettes that read as much like dramatic narratives as they do empirical records. These case studies - some detailed, others fragmentary - capture the high-stakes nature of surgery in a world without antibiotics, imaging, or reliable anesthesia. A dislocated shoulder smoothly reduced with Hippocratic leverage; a cranial injury trepanned in time to prevent fatal pressure; an amputation attempted too late, resulting in sepsis and death - each entry is both technical documentation and a meditation on uncertainty.

The Hippocratic Epidemics stands as an early forerunner to the modern case report. It includes dozens of such examples, where physicians chronicle patient symptoms, disease progressions, and the outcomes of interventions with striking honesty. Whether the outcome was favorable or fatal, the tone is never triumphant. There is no illusion of mastery - only the sense that knowledge must be recorded, studied, and ethically applied (5,10).

In some instances, particularly in trauma care, outcomes are surprisingly good. As documented in both Hippocratic treatises and Homeric epics, battlefield surgeons were able to extract arrows, splint fractures, and manage soft-tissue wounds with success rates that suggest technical competence and practical experience (45,46). Yet these same sources do not shy away from describing the limits of intervention—when infection set in, when shock overwhelmed the body, or when spiritual or familial taboos delayed treatment until it was too late (4,14).

Even in ophthalmic and dental care, success was tempered with caution. A cataract displaced but only partially restored sight; a tooth pulled too late to prevent systemic infection - these episodes reflect the fragile balance between therapeutic possibility and biological unpredictability (13,54).

What distinguishes ancient Greek surgical literature is not merely the presence of these cases, but the ethos they reflect. Surgery was not depicted as a realm of certainty, but of negotiation - between patient and physician, between illness and intervention, between human will and divine order. The surgeon was no magician, nor mere craftsman. He was a practitioner of phronesis - practical wisdom - whose greatest tool was not only the knife, but the humility to know its limits. The cumulative contributions of pioneering figures such as Erasistratus, Herophilos, Galen, and Paul of Aegina not only advanced surgical practice in their time but also laid the foundational principles for medical education and operative technique for centuries to follow (*Fig. 4*). These individuals exemplify the diverse intellectual and clinical legacies that defined ancient Greek surgery - from anatomical precision

Figure 4. Pioneers of Ancient Greek Surgery. Portraits of influential figures in the history of Greek surgical thought and practice. A. Erasistratus (c. 304 – c. 250 BCE), renowned anatomist and royal physician at the court of Seleucus I Nicator, known for his work on the brain and circulatory system. (Courtesy: Musée Ingres-Bourdelle – Étude pour La Maladied'Antiochus, ou Antiochus et Stratonice; busted'Erasistrate, c. 1860 – Ingres, MI.16.1.3). B. Herophilos of Chalcedon (c. 335–280 BCE), the first anatomist to systematically dissect human cadavers in Alexandria, advancing knowledge of the nervous system and cerebral ventricles. (Public domain). C. Galen of Pergamum (c. 129–216 CE), prolific physician and philosopher whose writings on anatomy, physiology, and surgery shaped medical thought for over a millennium. (Courtesy: P. R. Vigneron, 1820–29, via Wellcome Library, London). D.Paul of Aegina (c. 625–690 CE), Byzantine physician whose surgical manual Medical Compendium in Seven Books preserved and systematized classical techniques for later generations. (Public domain).

to systematized intervention. Ultimately, the legacy of Greek surgery lies not in the perfection of its instruments or the elegance of its incisions, but in its commitment to observation, adaptation, and ethical restraint. In every success, a measure of fortune; in every failure, a lesson for those who would read and remember.

Limitations, Risks, and the Culture of Surgical Restraint

For all their skill and creativity, ancient Greek surgeons practiced within a landscape of fragility - technical, ethical, and existential. Every operation was a wager, not just on anatomy or training, but on time, infection, and fate. In a world where the body was sacred and illness might be read as divine judgment, surgery was never a purely medical act; it was an intervention at the limits of what was knowable and permissible (7).

Infection, Pain, and Survival

The Hippocratic and later Galenic texts are unflinching about surgical danger. Wounds could "putrefy"; set bones might never knit; a routine lancing of an abscess could spiral into systemic failure. Without antibiotics, antiseptics relied on wine, vinegar, brine, or boiling water - crude by modern standards, but surprisingly methodical in their application (5). Fevers following surgery were often attributed to imbalance or divine wrath - an implicit recognition of infection before its microbial cause was understood. Hippocrates, in the Epidemics, refers to fevers arriving "as if from the gods," a haunting reminder of how fragile recovery could be once the wound was closed (23).

Pain, too, was ever-present. While Greek physicians understood the need to alleviate suffering, full anesthesia was beyond their reach. Analgesic substances like wine, mandrake, poppy, and hellebore were applied to reduce pain or induce sedation, but outcomes varied widely. Patients often faced procedures in full consciousness - biting leather, gripping hands, or fainting mid-operation. The guidance to surgeons was consistent: act quickly, confidently, and above all, know when not to proceed (16).

Despite these limitations, Greek medicine developed surprisingly effective early models of pain management. Empirical "pharmacies" drew on a wide range of botanical and mineral substances - opium, belladonna, henbane, and cold compresses among them. These were administered by trained healers or pharmakoi, sometimes in ritual contexts, sometimes in emergent battlefield or urban care settings. Over time, these traditions evolved into rational pharmacopoeias, forming the intellectual foundation for later pharmacology and pain theory (59).

One striking example is the so-called "Olympic Victor's Dark Ointment" (OVDO) - an opium-based salve referenced in classical sources. Modern chemical analysis has confirmed that when applied to the skin, OVDO delivered morphine transdermally with surprising efficiency - approximately 25% as effective as a modern opioid patch. This far outperformed even a direct opium solution, suggesting that ancient Greek healers developed both an empirical and functional understanding of drug delivery systems long before such knowledge became formalized in modern science (60).

Ethical Dilemmas and Limits

Long before formal medical codes were established, ancient Greek thought had already begun shaping a profound ethical consciousness around healing. Mythology offered foundational moral templates: stories such as those of Apollo, the divine healer, and Asclepius, his mortal son turned god of medicine, emphasized the physician's dual role as agent of both healing and restraint. The myth of Chiron - the wise centaur who mentored Achilles and other heroes - exemplified the physician-teacher as a moral guide, not just a transmitter of technique. These narratives cultivated values such as compassion, reverence for life, and moral responsibility, themes that would later echo in the Hippocratic Oath and the broader tradition of Western medical ethics (11,61).

Beneath every surgical act lay a fundamental question: not just can we operate, but should we? Greek physicians were deeply aware of the moral stakes. To cut, to cauterize, to amputate - each carried the risk of harming a body that was both biologically fragile and socially sacred. The Hippocratic principle of primumnon nocere - first, do no harm - was no empty phrase. It was born of a reality in which the surgeon's error could mean the patient's death, the healer's disgrace, and the community's loss (12). To contextualize the enduring moral influence of Hippocrates on ancient surgical ethics and the professional responsibilities of physicians, *Fig. 5* presents iconic visual references to Hippocrates himself, the Hippocratic Oath, and the corpus of texts that

Figure 5. The Legacy of Hippocrates: Foundations of Ancient Medical Ethics and Knowledge. Visual materials representing the enduring influence of Hippocrates, often regarded as the father of Western medicine, and the textual heritage attributed to his teachings. **(A)** Traditional depiction of Hippocrates, featured in HippocratisIusiurandum, underlininghis iconic role in shaping medical ethics and professional identity. **(B)** Manuscript representation of the Hippocratic Oath, one of the earliest articulations of medical ethics, emphasizing principles of non-maleficence, confidentiality, and professional integrity. **(C)** Title page or cover of ApantaHippokratous (Omnia Opera Hippocratis), the collected works of Hippocrates, reflecting the scope of his contributions to clinical observation, prognosis, and surgical practice.

helped define the boundaries of medical intervention and restraint.

Surgical intervention in ancient Greece thus often involved careful ethical calculus. Physicians had to balance urgency with humility, innovation with tradition, and the patient's welfare with their own professional reputation. Failure was not just a technical problem - it could lead to lawsuits, exile, or permanent damage to one's standing in civic life. The consequences of misjudgment were social as much as medical. Amputations, for instance, are discussed in medical literature with precise terminology, yet the tone is never cavalier. Such procedures were reserved for extreme cases - gangrene, traumatic destruction, or war injuries where no other option remained. The decision to sever a limb was not taken lightly, and even when technically successful, it was seen as a tragic compromise: the saving of a life at the cost of wholeness (14,62).

Ultimately, ancient Greek surgery was practiced not in a moral vacuum but within a culture deeply attuned to the fragility of both body and soul. The surgeon stood at the intersection of knowledge and conscience, a technician of flesh and a steward of human dignity.

The Limits of Knowledge

Despite the impressive breadth of technical detail in ancient surgical treatises, a persistent theme runs beneath the surface: uncertainty. The texts are filled not only with instructions but with warnings - often terse, sometimes poetic. "If you do not know, do not cut," one passage advises. Another cautions, "Avoid deep wounds; the gods dwell in hidden places." These aphorisms are more than superstition; they reflect a worldview in which surgical intervention was never fully separated from metaphysical risk or moral consequence (4,7).

Greek surgeons, for all their skill, understood that knowledge had limits. The body was complex, its inner workings partly observable, partly veiled in mystery. The anatomical frameworks they developed - through dissection, experience, and theorizing - were groundbreaking but also fragmentary. Without modern diagnostics or anesthesia, the line between help and harm was razor-thin. As a result, the literature does not celebrate mastery but emphasizes caution, discretion, and the recognition that healing sometimes meant not intervening (5,13).

The Hippocratic texts, particularly those in the Corpus Hippocraticum, urge physicians to acknowledge what they do not know. Galen, too,

despite his monumental anatomical writings, frequently admits the incompleteness of knowledge, pointing to nature - and by extension, the divine - as the ultimate architect of the body (1,12). These acknowledgments reveal a deep philosophical humility. Surgical wisdom, in this tradition, was not the arrogance of command over nature but the discipline of listening, observing, and sometimes stepping back.

Such restraint was not weakness but a principle of practice. In a world where medical failure had both mortal and social consequences, the wisest physicians were often those who chose to delay - or even to do nothing. For the Greeks, the limits of knowledge were not a source of shame but a necessary boundary, guarding against the overreach of hubris and reminding the healer of their place in a universe governed by forces not entirely their own (4,7).

The Ethics of Display and Experimentation

Not all surgery in ancient Greece unfolded behind closed doors. In certain contexts - especially during military campaigns or within academic hubs like Hellenistic Alexandria - intervention became spectacle. Early Alexandrian medicine, while rooted in the Hippocratic tradition, marked a turning point in medical history through its emphasis on anatomical investigation. Public demonstrations of anatomical knowledge, battle-field operations under the gaze of soldiers and commanders, and even live dissections of criminals pushed the boundaries of what was ethically acceptable in the name of science (7,62). These acts, while contributing significantly to anatomical and physiological understanding, exposed the uneasy intersection of curiosity, authority, and the vulnerability of the human body.

In Alexandria, particularly under rulers who promoted scholarship and tolerated moral experimentation, physicians such as Herophilus and Erasistratus are reported to have conducted vivisections on condemned prisoners. Though debated by historians, these accounts - documented by later Roman and Byzantine sources - illustrate the era's ambivalence: a rational commitment to learning confronted by the ethical cost of its methods (62-63). Dissection and experimentation were no longer wholly taboo, but they existed in a liminal space - justified as service to knowledge, but not without philosophical and moral discomfort. Herophilus of Chalcedon played a central role in this transformation by systematically studying the human body through dissection. He advanced knowledge in areas such as the nervous system, distinguishing between sensory and motor nerves, and offered detailed descriptions of organs including the brain, eye, and reproductive system. This approach reflected a shift from purely theoretical medicine to one based on empirical observation and anatomical evidence, laying the foundation for scientific medicine in the Hellenistic world (64,65).

In sum, the ethics of ancient Greek surgery were neither static nor naïve. They evolved with technique, shaped by societal norms, religious values, and philosophical inquiry. Whether operating in the home, battlefield, or amphitheater, the ancient surgeon carried not just tools, but questions - about suffering, justice, and the price of understanding. These practices were always shadowed by risk and restraint, governed not only by skill but by a deep awareness that not every wound - literal or moral - could be closed (1,12).

Legacy and Reception: The Afterlife of Ancient Greek Surgery

The legacy of ancient Greek surgery is not a linear tale of progress but a layered palimpsest - full of erasures, emendations, and reinventions. Its echoes resound across centuries and continents, resurfacing in the amphitheaters of Alexandria, the infirmaries of Byzantium, the libraries of Baghdad, and the anatomical theatres of the Renaissance. Revered and reinterpreted, the surgical knowledge of the Greeks formed the bedrock upon which generations of healers built, challenged, and redefined their practice (7).

Transmission and Transformation

The surgical writings of Hippocrates and Galen became foundational to medical education in the Greco-Roman world and beyond. Through translations into Latin, Syriac, and Arabic, these texts reached the intellectual centers of the Islamic Golden Age and later Renaissance Europe. From Alexandria to Constantinople, and Cordoba to Salerno, physicians studied and debated the insights of their ancient predecessors (13,66).

Arab scholars such as Al-Zahrawi (Albucasis) not only preserved Greek surgical knowledge but also expanded it - systematizing procedures, improving cautery techniques, introducing novel

suture materials, and refining surgical instruments. Their commentaries and manuals did not merely transmit Greek ideas; they reimagined them, contributing innovations that would be further developed in medieval and early modern Europe (13,67,68). *Fig. 6* visually captures the pivotal role of Al-Zahrawi in the preservation and expansion of ancient Greek surgical traditions, illustrating both the symbolic and textual transmission of medical knowledge from antiquity to the Islamic Golden Age and beyond.

Over time, commentaries on Greek authors became a scholarly tradition in themselves. Some followed Hippocratic restraint with reverence; others questioned Galenic anatomical claims through empirical experimentation, especially as dissection became more common (69). To better illustrate the key figures who shaped the development of ancient Greek surgery and its transmission across historical periods, *Table 1* summarizes notable personalities, their contexts, and their primary contributions.

Table 1. Key Figures in the History and Transmission of Ancient Greek Surgery.

Name	Lifespan	Location of Practice	Main Contributions
Hippocrates	c. 460 – c. 370 BCE	Kos, Greece	Father of medicine; surgical treatises on fractures and dislocations; invented surgical instruments like the ambe; emphasized clinical observation and ethical restraint.
Herophilos of Chalcedon	c. 335 – c. 280 BCE	Alexandria, Egypt	First to conduct systematic human dissections; identified brain as seat of intellect; advanced understanding of nerves, blood vessels, and cerebral ventricles.
Erasistratus	c. 304 – c. 250 BCE	Alexandria, Egypt	Pioneered anatomical study; studied heart and circulatory system; described heart valves; opposed bloodletting; differentiated between sensory and motor nerves.
Archagathus	fl. c. 219 BCE	Rome (Greekorigin)	First known foreign surgeon in Rome; used knife and cautery extensively; originally respected, later called carnifex (executioner) due to aggressive treatments.
Asclepiades of Bithynia	c. 124 – c. 40 BCE	Rome (Greekorigin)	Advocated gentle treatments; proposed bronchotomy; emphasized hygiene and diet; rejected Hippocratic humoralism.
Ammonius of Alexandria	1st century BCE	Alexandria, Egypt	Known as Lithotomus; first to perform lithotrity (breaking bladder stones); early urological surgery innovator.
Celsus	c. 25 BCE – c. 50 CE	Rome	Compiled Greek medical knowledge; detailed surgical procedures including lithotomy and infibulation; described ideal surgeon's character and technique.
Aretaeus of Cappadocia	1st century CE	Cappadocia, Asia Minor	Primarily a physician; skeptical of bronchotomy; emphasized disease descriptions; offered critical perspective on surgical interventions.
Caelius Aurelianus	5th century CE	North Africa (Roman province)	Preserved Greek medical knowledge; rejected bronchotomy; documented rare cases like thoracic trauma survival and ascites surgery.
Galen of Pergamum	c. 129 – c. 216 CE	Pergamum, Rome	Most influential medical writer of antiquity; extensive anatomical and surgical texts; commented on Hippocratic surgery; practiced surgery early in career.
Antyllus	2nd century CE?	Unknown (possibly Rome)	Developed tracheotomy technique; contributed to vascular surgery (e.g., aneurysm treatment); widely quoted by later authors like Paul of Aegina.
Oribasius	c. 320 – c. 400 CE	Constantinople	Physician to Emperor Julian; compiled earlier medical texts; preserved fragments of Antyllus and others; focused on practical surgery.
Aëtius of Amida	6th century CE	Amida (modern Diyarbakır)	Compiled earlier Greek surgical knowledge; discussed ophthalmology and gynecology; preserved many ancient techniques and remedies.
Alexander of Tralles	6th century CE	Tralles (Asia Minor)	Combined surgery with internal medicine; focused on practical therapeutics; wrote on surgical diseases.
Paul of Aegina	c. 625 – c. 690 CE	Aegina (Byzantine Empire)	Last great Greek surgical writer; wrote Medical Compendium in Seven Books; specialized in surgery, obstetrics, and gynecology; key source for Islamic medicine.
al-Zahrawi (Albucasis)	c. 936 – 1013 CE	Córdoba, Al-Andalus	Synthesized and expanded on Greek surgical knowledge (esp. Paul of Aegina); wrote Al-Tasrif, including detailed surgical instrument illustrations and techniques. (Arabicscholar)

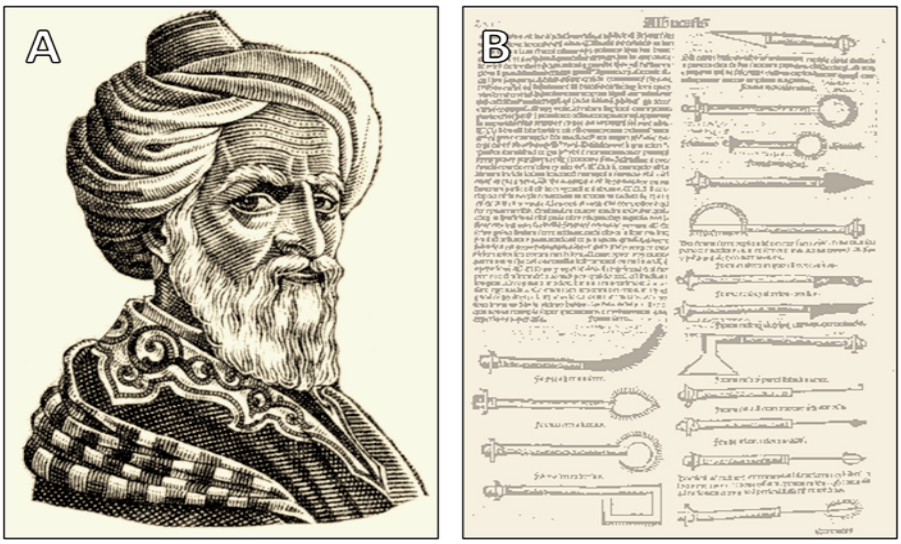

Figure 6. The Transmission of Greek Surgical Knowledge Through al-Zahrawi (Albucasis). This figure highlights the enduring legacy of Greek surgical practice as preserved and transformed by Islamic scholars during the medieval period, particularly through the influential work of al-Zahrawi. **(A)** Imaginary portrait of al-Zahrawi (Albucasis), the prominent 10th-century Andalusian physician and surgeon, as featured on a 1964 Syrian postage stamp. Though no authentic likeness survives, the image symbolizes his esteemed place in medical history as a transmitter and innovator of Greco-Roman surgical knowledge. (Courtesy: Syrian Postal Authority). **(B)** Illustrated page from a 1531 Latin edition of Liber Chirurgiae, the surgical treatiseof Al-Zahrawi, translated by Peter Argellata. The text details a wide array of surgical procedures and instruments, many of which trace their origins to Greek sources. This work became a standard reference in European medical schools for centuries.
(Courtesy: Public domain / Historical medical archives).

Renaissance Rediscovery and the Rise of Anatomy

The Renaissance revived a passion for classical knowledge, but also brought a shift: ancient texts were no longer read as unquestionable authority. Surgeons such as Andreas Vesalius embraced the anatomical descriptions of Galen while simultaneously challenging them through hands-on dissection. His seminal work, de humani corporis fabrica, marked a turning point where direct observation began to supersede textual tradition (70,71).

Anatomical theatres emerged as spaces of spectacle and scholarship - where the mysteries of the human body were publicly unveiled. Despite this growing scientific confidence, the spirit of Greek surgical caution endured. Many physicians still cited Hippocrates on the risks of invasive treatment, the unpredictable course of healing, and the ever-present possibility of failure (12,25).

Caution and Creativity

In the modern operating room, ancient Greek surgery remains present not as a set of tools, but as a framework of thought. The dramatic advances in anesthesia, imaging, and asepsis have changed the technical odds - but not the essential dilemma. Every surgery continues to walk the tightrope between necessity and risk, innovation and restraint (12,14).

The ethical complexities of modern surgery - encoded in medical oaths, institutional protocols, and ethical review boards - can trace their lineage to Greek philosophical traditions. The imperative to “do no harm” endures not as an empty slogan, but as a moral compass inherited from a world where the surgeon's success could mean reverence or ruin.

Cultural Memory and the Myth of Progress

Popular imagination continues to draw from the mythos of ancient Greek surgery. Whether in film, literature, or historical retrospectives, the image of the calm, courageous physician - engaged in a delicate, almost sacred struggle against disease - remains vivid. These narratives are not just

nostalgic tributes; they are cautionary tales that remind us that surgical mastery is never merely technical. It is also philosophical, emotional, and ethical - a dialogue between hubris and humility, science and soul.

Discussion

Looking across the vast and layered history of Greek surgical practice, what emerges is not a triumphant march of technical mastery, but a continuous struggle with uncertainty. Ancient Greek surgery was never simply about cutting or curing - it was always a delicate negotiation between bold intervention and cautious restraint, between scientific curiosity and moral concern (4,7). The tension between action and abstention, innovation and humility, was not a flaw of the tradition but its defining feature.

When to Cut, When to Wait

No ancient surgeon operated with the illusion of certainty. Every incision represented a step into unknown territory, armed with little more than empirical observation, inherited techniques, and a deep respect for the body's own capacity to heal. The Hippocratic treatises are marked by a curious dual tone: confident in technique, yet haunted by the dangers of overreach. "Attempt only what you know," they warn. "Operate only when necessary. Trust the body when it can be trusted" (5,12).

This ethos reflects not cowardice, but caution born of experience. Surgery was never routine; it was exceptional, risky, and often irreversible. The penalty for misjudgment could be death - not just for the patient, but for the physician's reputation and standing in the community. In this context, surgical restraint was not passivity but profound moral deliberation.

Pain and the Limits of Empathy

Pain, unmitigated and omnipresent, defined the surgical experience in antiquity. Without anesthesia, even the simplest procedure could become an ordeal. Greek physicians relied on local applications of wine, opium, or mandrake root, but these offered only partial relief. The surgeon had to perform quickly and decisively while confronting the visible suffering of the patient - a test of both technical and emotional resilience (14,16).

The literature reveals a consistent emphasis on the psychological fortitude of the practitioner: the ability to act with urgency but not indifference, to remain calm amid screams and convulsions, to stop when further intervention would bring more harm than healing. Ancient Greek surgery, in this sense, was not only a clinical act but a moral trial.

Knowledge, Doubt, and the Ethics of Experimentation

Despite their reverence for Hippocratic and Galenic authority, Greek physicians were far from doctrinaire. Their texts are filled with hesitation, ambiguity, and the acknowledgment of limits. They asked hard questions: When is treatment worse than disease? When does intervention become experimentation? When is ignorance a reason to abstain rather than proceed?

Perhaps the most remarkable feature of these writings is their honesty. "In these cases, I do not know what to do," admits one author - a rare and radical act of intellectual humility (7). This openness to uncertainty remains a profound legacy. In an era of growing technological confidence, the Greeks remind us that surgical wisdom often lies in knowing when not to act.

Beyond the Scalpel: A Philosophical Inheritance

While the technical armamentarium of ancient Greek surgeons has long since been surpassed, their ethical frameworks continue to resonate. Informed consent, risk-benefit analysis, and the principle of non-maleficence are not modern inventions; they have deep roots in the ethical reflection of classical medicine (12,66).

The myth of linear progress - that medical science always improves - sits uneasily beside the Greek experience. Even today, complications persist, outcomes remain uncertain, and the limits of intervention demand constant reevaluation. The Asclepian tradition teaches that technique alone is not enough (11). Surgery requires not only skill, but judgment, humility, and the courage to refrain.

A Cautious Courage

If ancient Greek surgery offers a single enduring lesson, it is not found in the details of trepanation or fracture reduction, but in an ethical posture: a fusion of caution and courage, of daring tempered by doubt. To operate is, in a sense, to trespass - to act where fate, nature, or divinity may already be at work. The best surgeons of antiquity understood

this and did not act lightly. Their legacy is not in the tools they used, but in the restraint they exercised. The greatest surgical act, then as now, may be the moment when the scalpel is set aside - not out of fear, but out of wisdom.

Limitations

This study is inherently constrained by the nature of its sources, which include fragmentary ancient texts, secondary historical analyses, and archaeological interpretations. Many surgical practices of antiquity were transmitted orally or recorded centuries after their original use, complicating efforts to reconstruct them with full accuracy. Furthermore, while medical treatises provide valuable insight, they often reflect idealized procedures rather than routine clinical realities. The absence of standardized terminology, variable translation quality, and cultural biases - both ancient and modern - also limit definitive conclusions. Finally, the selection of literature, though based on relevance and scholarly rigor, cannot fully capture the entirety of ancient surgical experience across all regions and periods of Greek antiquity.

Conclusion

Ancient Greek surgery stands as a complex intersection of empirical skill, ethical reflection, and cultural meaning - a practice shaped as much by philosophical restraint as by technical ingenuity. From orthopedic reduction and battlefield trauma care to cranial trepanation, ophthalmic interventions, and facial reconstruction, Greek surgeons demonstrated remarkable anatomical understanding and surgical creativity despite operating without modern tools such as anesthesia or antibiotics. Their treatises reveal not just procedural knowledge but a deep awareness of risk, pain, and the limits of human power. Surgery was never purely technical - it was embedded in religious, social, and moral frameworks, where every decision to cut was shadowed by doubt, humility, and reverence for life. Myths, ethical codes, and case reports reinforced a cautious courage: to act only when necessary, to avoid harm, and to recognize when intervention might cause more suffering than healing. This manuscript has traced how these practices evolved within a framework of philosophical tension - between hubris and healing, boldness and restraint - and how they continue to resonate in today's surgical ethics. The legacy of ancient Greek surgery is not a linear tale of progress but a timeless meditation on the human condition, reminding us that every act of healing must also be an act of profound moral judgment.

Conflicts of Interest

The authors declare no conflict of interest.

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