Detail of a miniature of the martyrdom of St Appollonia, from the Dunois Hours, France (Paris) c1440-1450CE, Yates Thompson MS 3, f. 284v

An Overview of Dental Surgery in Europe, North Africa, and the Near East: From Antiquity to 1600 CE

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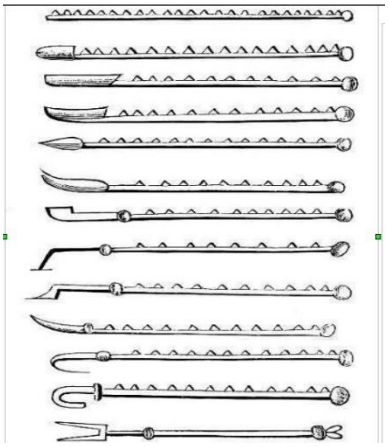


Dental scalers, from “On Surgery and Instruments” by Albucasis, late 10th cen CE

Introduction

My interest in historical dental techniques stems from my career as a dental assistant. One day many years ago I was browsing a trade magazine for hygienists and came across a brief mention of Elizabethan tooth bleach. Searching for the recipe led me down the rabbit hole of 16th century dental texts, which in turn led to me branching out into earlier times, general surgery, herbology, and dabbling in alchemy. This paper is the culmination of all I have learned so far about dental surgery; there are many trails of information I have yet to fully explore.

In this paper I will present major theories and technical advancements in roughly chronological order. There was extensive interaction between the various cultures of Europe, the Near East, and North Africa through most of the time period included, especially among the educated classes, so theories and techniques that were pioneered in one place usually spread fairly quickly throughout the larger region. I have chosen to omit information about the rest of Africa, Asia, and the Americas since I have not done much reading on those branches of medicine, although there was interaction between those cultures and Europe in period.

What Health Problems Were Dental Practitioners Trying to Solve?

Throughout the history of Homo sapiens (and indeed the earlier Homo species that we have discovered so far), a few specific dental problems have plagued us: abrasion/wear, caries/cavities, and periodontal/gum disease. These three conditions

can be seen from the earliest extant skulls all the way through to the modern dental office. The history of dentistry is the history of attempting to treat these diseases.

Major advances in dental surgery

Babylon

The earliest texts we have that discuss dental disease are from Babylon. This appears to be the origin of the theory that tooth pain is caused by tooth worms burrowing into the tooth. Since caries cannot be seen by the naked eye until they are advanced enough to make a hole in the tooth, this would be an obvious explanation of what was observed. They explained the ebb and flow of tooth pain as the movement of worms inside the tooth. Treatments were aimed at driving the worm out of the tooth using various mouth rinses and poultices. (1)

Ancient Egypt

Beginning with ancient Egypt we have the benefit of both written descriptions of dental diseases and treatments as well as a large number of extant skulls to compare. In this highly stratified society, the differences in dental issues between upper and lower classes are prominent: the higher status individuals have higher rates of caries while lower status individuals have higher rates of abrasion. These differences reflect the differences in diet between the wealthy and the poor. (3) As we will see throughout history up until the 20th century CE, wealthy people ate a lot more refined carbohydrates which contribute to caries, while poor people typically ate minimally refined carbohydrates which contribute less to caries but more to mechanical wear due to high fiber content as well as sand from the process of grinding grains with stone which were more likely to be sifted from flour used to feed the wealthy. We also see that caries rates increased significantly from the Predynastic period through the Dynastic and into the Ptolemaic period, coinciding with dietary changes over time towards more sugary foods (3).

Egyptian skull c. 1,500 BC. Courtesy of the Duckworth Collection, Cambridge University showing extensive tooth wear

Restorative dental treatments (those that halt the progression of disease and restore the missing portions of the diseased tooth) were minimal in this era (4). There is no evidence, either written or physical, to suggest that any tools were used to remove decayed tooth structure or whole teeth. It is possible that some medical tools were multi-functional and used in dentistry but there is little to no evidence of use on extant teeth and no direct textual evidence.

By observing extant skulls we see that caries were treated by filling the hole with medicaments, which would have done little to stop the disease progression but may have provided some temporary relief of tooth sensitivity by insulating the exposed inner tooth structure(4). Some ingredients may have had mild antimicrobial properties but would have minimal effect on caries since the *Streptococus mutans* bacteria which causes caries is adept at penetrating tooth structure so any topical medicament would only affect the bacteria closest to the surface. These mild antimicrobial effects would also have been counteracted by the use of binding agents high in carbohydrates, mostly wheat flour and honey (while honey is antimicrobial, *Strep mutans* has developed the ability to metabolize the sugars in honey without being affected by the enzymes). Soft filling materials would quickly wear away and would do nothing to replace missing tooth structure.

Egyptian mandible c. 1,500 BC. Courtesy of Duckworth Collection, Cambridge University, showing wear and bone loss due to periodontal disease

Localized areas of periodontal disease was somewhat common as we see in the skulls – deposits of calculus were widespread although periodontal bone loss was less common than in later eras due to the lower amount of fermentable carbohydrates in the typical Egyptian diet of this period (3). The medical papyri we have so far discovered and translated give a number of treatments for mobile teeth, all of which are for medicaments similar to the ones prescribed for caries. These were packed around the loose teeth and seem to have been an attempt to mechanically stabilize them (3,4). Some prescribed ingredients (ochre, malachite, terebinth resin) have antimicrobial and astringent properties which would bring down gingival inflammation in the short term but packing the teeth with foreign material would in the long term cause even more inflammation and therefore more bone loss.

Egyptian skull circa 2000 BCE, showing avulsed teeth that have been wired into place and periodontal disease on surrounding teeth

Some extant skulls show teeth which have been lost to periodontal bone loss or avulsion (knocked out with blunt force) which have been secured to the surrounding teeth with wire (see above image) but evidence is inconclusive as to whether this was done during life or after death as part of preparing the body for the afterlife (3,4).

Estruscans

Etruscan bridge circa 500 BCE, reconstruction

The Etruscans, a pre-Roman culture in Tuscany and Umbria, are the first we have discovered that created removable dental prostheses. Etruscan literature mentions wealthy women wearing and removing teeth like they put on and remove clothing and wigs – this indicates that unlike the Egyptian bridges, these were unquestionably worn during life (1). By far the most common teeth included in these protheses are the incisors. Due to the anatomy of the human mouth, incisors are the most likely teeth to be lost due to either periodontal disease or trauma, and are also the most visible.

Ancient Greeks

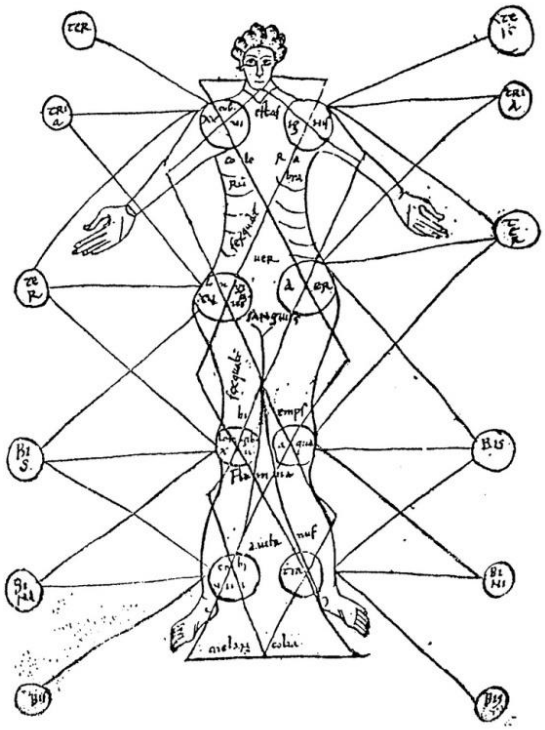


Chart of the humors and their place in the body, Burgos de Osma, Spain; eleventh century

From roughly 500 BCE until the discovery of microbes, the humoral model of medicine was the foundation of all scientific medical study in Europe, North Africa, and the Near East. The writings of the classical Greeks, especially Hippocrates (ca 460-370 BCE), were the foundation of all medical science in this part of the world for approximately 2300 years (1). Their main contribution was formalizing the theory of the humors: four elements that make up and influence all things in nature, including the human body. In this model, disease is caused by an imbalance in the body between heat, cold, dryness, and moisture. This applied to any dental problem without an observable cause. Teeth with visible caries were still diagnosed with tooth worms, and herbal remedies meant to drive out the worms would be prescribed. Dental surgery in Greece during this time was limited to extractions but herbal remedies abounded (4).

The Greek authors did mention some herbs that could be used as pain relief and as sedatives for surgery such as henbane, opium poppy, and mandrake but anesthesia did not exist until much later (1,4). Authors such as Dioscorides cautioned against using sedatives except in serious circumstances because it was very easy to overdose the

patient and kill them (3). The main method of attempting to relieve pain was by balancing the humors (2).

Romans

Teeth retrieved from a drain in the Roman Forum, showing deep interproximal caries consistent with a diet high in refined carbohydrates (3)

Roman medicine was directly based on Greek science. Dental problems were treated with herbal remedies until extraction was necessary (1,2,4). As the Roman diet was relatively high in carbohydrates we see a high incidence of caries in all social classes, but following the previous patterns, the higher a person's social status the higher the rate of caries, generally. With such a high rate of tooth loss, Roman practitioners created removable prosthetics similar to the Etruscans but of higher quality (2,3). These prosthetics could be made from a patient's own teeth, the teeth of another person, or animal bone (4).

By far the most influential Roman medical author was Galen (approx. 131-216 CE) (1,2,4). His books were translated into many languages over the following centuries,

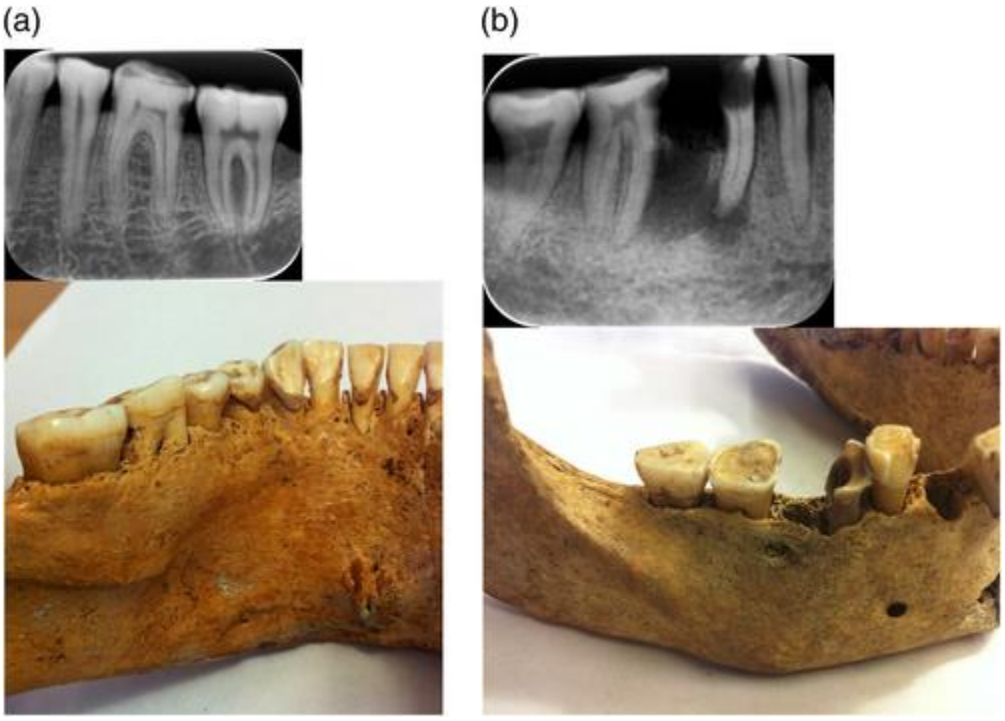
and were commented on extensively by future authors. He did not, however, add much to the practice of dentistry: most of his treatments were herbal and the only oral surgery he recommended was extraction. Due to legal limitations on dissection of human bodies, his knowledge of anatomy was mostly theoretical based on animal anatomy (1,2,4) and therefore often wrong but it was believed to be accurate and authoritative.

Viking Age Scandinavia

Norse decorative tooth grooves in a skull which also shows significant wear and periodontal disease, 9-11th cen Gotland (2)

Many Viking age skulls have been excavated and almost all show significant wear, generalized periodontal disease, and mild to moderate caries. Given what we know about the Scandinavian diet of that era this is not surprising; wear would be due to a high amount of roughage in stone-ground flours, and caries can be attributed to consumption of honey, beer, and dried fruit/berries. We have found no evidence of regular plaque removal so periodontal disease is expected. No extant skulls show evidence of restorative dental work other than possibly extraction; it is not usually

possible to determine whether a tooth was removed by tools or if it came out purely as a result of extreme bone loss (1,5,6,7).



Viking age mandibles discovered in Sweden, showing dental wear, caries, an apical abcess, and periodontal disease (7)

The defining feature of Viking age dentistry is the completely unique application of decorative tooth alteration. Very few human cultures have practiced cosmetic tooth shaping, and the inhabitants of Gotland are the only example in the entire history of Europe (3,4,6). One hundred thirty skulls have been discovered which feature grooves filed into the enamel of the upper incisors, all but 3 of which were buried on Gotland. Most of these grooves are straight horizontal lines, although a few skulls have curved lines and fewer still have vertical lines. Some grooves contain particles of blue or red dye. These grooves are only in the outer enamel portion of the teeth so the filing could have been done with minimal pain to the subject.

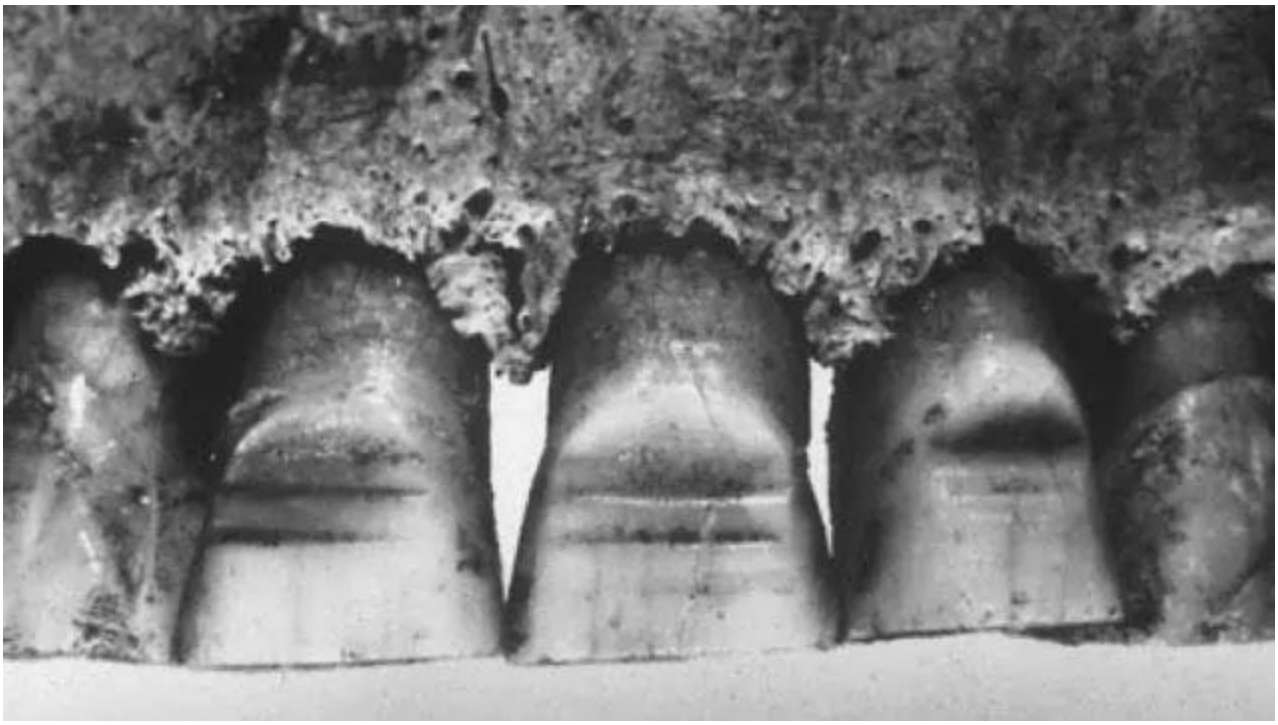
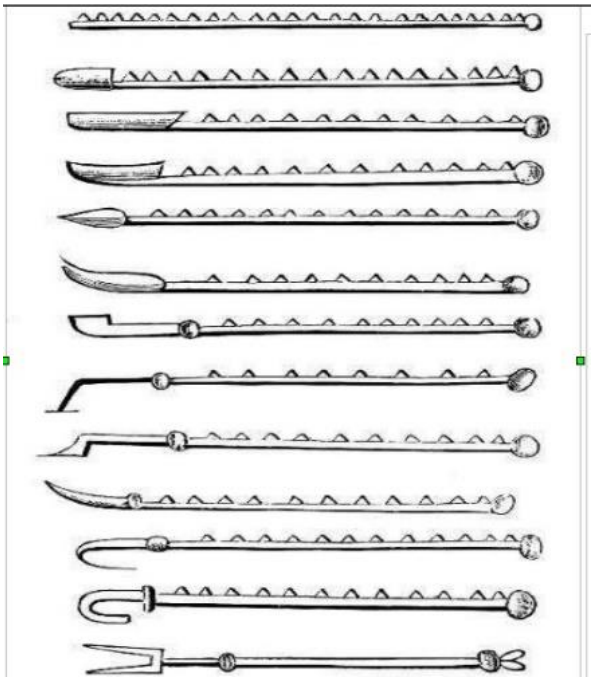


Image credits: Stefan Lovgren, via National Geographic (2)

It is thusfar unknown what inspired this trend; it may have been a spontaneous invention. It also may have been inspired by brief contact with African and/or North American cultures which practiced decorative tooth filing although those cultures are mostly outside of the known contemporary range of the Norse and are significantly different in style. Regardless, the patterns observed in Gotland are unique to that culture and appear to have been fashionable for only about 250 years (approximately 800–1050 AD). So far there is no evidence of the social significance of this filing other than its almost total restriction to biological males buried in Gotland. No written reference to the practice has been found so far and the filed teeth do not correspond to an age group or social status (2,3,4,6).

Jawbone, helmet and weapons, at Vikings: Life and Legend, British Museum, London. (8)

North Africa and the Near East During the Early Middle Ages



Dental scalers, from “On Surgery and Instruments” by Albucasis, late 10th cen CE (3)

From roughly the 9th century until post-Bubonic Plague, Islamic cultures were on the cutting edge of medical knowledge and surgical innovation. They produced translations of Galen and Hippocrates, as well as a number of commentaries which expanded on the work of these greats and added their own treatments, as well as incorporating treatments pioneered in India (2,3,6). These were widely distributed throughout Europe.

One of the most famous surgical authors of this time period was Abu ‘l-Qasim Khalaf ibn ‘Abbas al-Zahrawi, known in Europe as Albucasis (died circa 1013 CE) who lived the majority of his life in Cordoba and published a book containing the most up-to-date techniques of the time (3,4,6,7). The humoral theory of medicine still dominated and herbal remedies for dental issues proliferated (1,2,3,6).

The biggest contribution that Islamic practitioners made to dentistry was a focus on oral hygiene. Previous and contemporary cultures made little to no mention of oral hygiene

beyond mouth rinses, and extant skulls show the expected prevalence of dental calculus and associated periodontal disease. Albucasis wrote about the importance of regular removal of dental calculus for oral health, and invented metal hand scalers for the removal of said calculus (4,6,7). Modern medicine has shown that the presence of dental calculus causes chronic inflammation of the gingiva and periodontal bone which inevitably leads to the body resorbing bone to move away from the irritant. Albucasis described this process although from the point of view of humoral theory (7).

Dental surgery in this era seems to have been limited to extractions, cautery, and occasional splinting of loose teeth (1,2,3,7). Herbal remedies for toothache were still common. Albucasis recommended heat cauterization of apical abscesses and toothaches that do not respond to herbal remedies. As the Romans described, he recommended only extracting teeth as a last resort and cautioned against leaving root tips in the bone after removal as they could cause future infection. Albucasis also described using silver or (preferably) gold wire to splint front teeth that had been knocked loose. He also suggested that if front teeth are lost, they can be wired back into place (7).

Europe Post-Iron Age to First-Wave Bubonic Plague

an anatomy class, from the Major Surgery of Guy de Chauliac (1364); a portrait of Guy de Chauliac (3)

This period of European medicine did not feature much innovation. Most medical training was based on Arab writings and commentaries on Greek and Roman texts, and the major European texts were largely compilations of writings by them. Theories of tooth pain were still based firmly on humoral theory (1,2,3,4,5,6). Extant skulls show the expected patterns of wear, periodontal disease, and caries consistent with what we know of diets.

Oral hygiene became a more important part of life during this time period. There are a lot of recipes for dentifrices and mouth rinses but very little mention of scaling although there are direct quotes from Albucasis' writings in the European texts so the concept was known (1,2,5). The dentifrices recommended were extremely abrasive so while they would have cleaned off plaque and stain, they also would have contributed to excessive wear over time.

Monasteries and abbeys were the main centers of medical learning in Christian Europe, with some physicians traveled to Muslim Iberia, Persia, or Baghdad to study at Muslim teaching hospitals. The Counsel of Tours in 1163 changed the practice of medicine for several centuries by declaring that it was inappropriate for members of the Christian clergy to cut into the human body; this led to a split between practitioners of herbal medicine who were highly educated and literate, and barber-surgeons who learned their trade through apprenticeships and did not publish (4). In this era dental surgery was restricted to cautery, draining abscesses, and extractions (1,4). These treatments were provided by either barber-surgeons or itinerate "tooth-drawers" who were decried as quacks with no training but who provided extractions for desperate people with no access to better options (4).

The most famous and comprehensive surgical text of this era is the Major Surgery by Guy de Chauliac (1298-1368). This text is an excellent example of the compilation style of medical writing as it quotes extensively from Greek and Roman authors as well as Arab and Persian authors and commentators, organizing information by topic. De Chauliac lists the disorders of teeth as toothache, decay, congelation, numbness, bad odor, loss of teeth, and looseness of teeth; he lists the causes as trauma or humoral imbalance. The treatments recommended are balancing the humors (through diet and/or topical application of herbs), bloodletting, cupping, draining abscesses, cauterization, and extraction. Fillings made of herbs and soft materials like mastic or wax were recommended for large cavities but such treatment would not have restored the tooth to normal function. De Chauliac made mention of splinting loose teeth with gold wire as described by Albucasis, and mentioned that missing teeth could be replaced with false teeth made of cow bone wired into place; this almost certainly was only used for front teeth for aesthetic purposes since such false teeth would not be strong enough to chew with (1).

Rennaissance Europe

The European Renaissance saw an explosion of medical writings. For the first time in

centuries, European physicians went back to the definitive texts of Galen and Hippocrates and questioned what they wrote. In the realm of surgery, this manifested in new research into anatomy and physiology. Medical learning became largely detached from the Church and as such, previous taboos against cutting into the human body were discarded. Herbal treatments continued to be the main method of treating dental issues and many authors recorded unique remedies (3,4,5,6,7,10,12)
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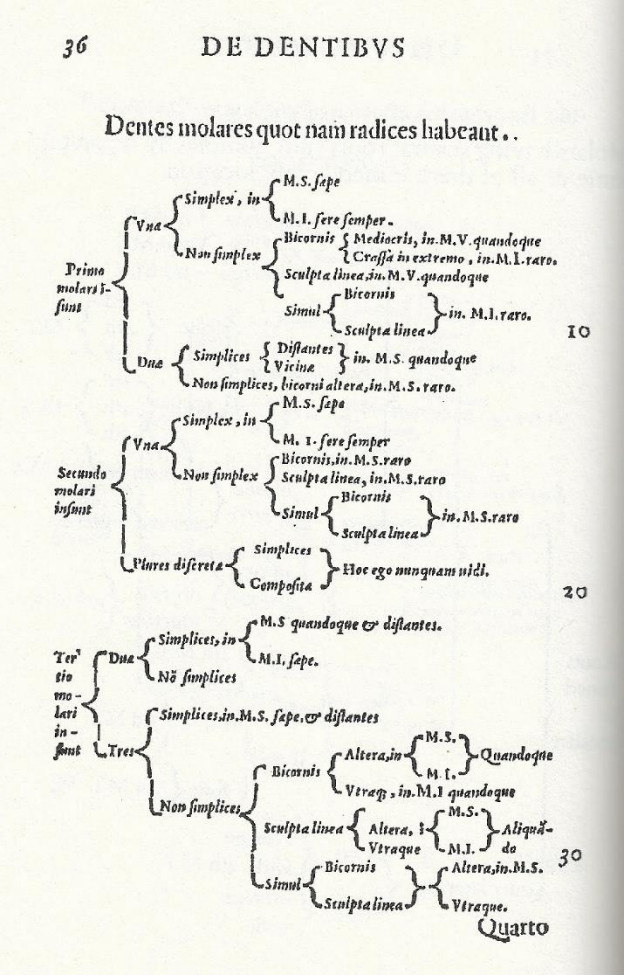
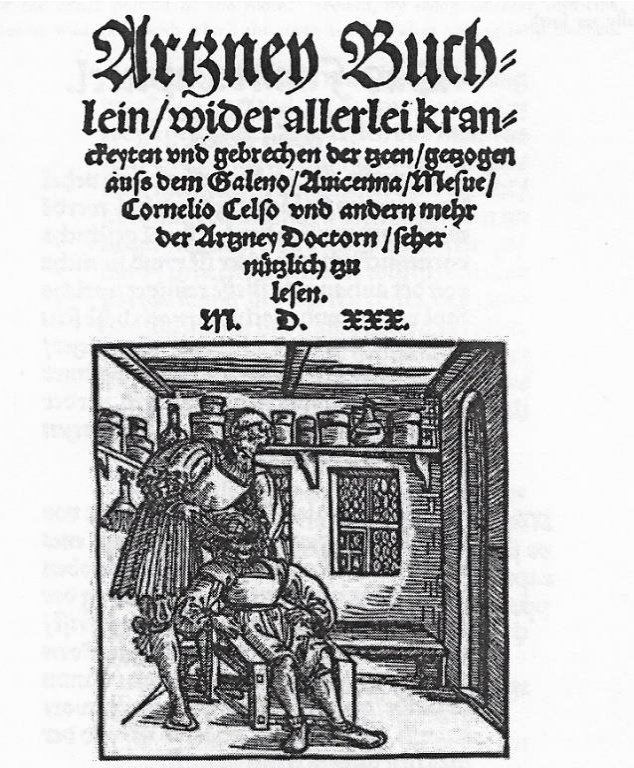


From *Libellus de Dentibus* by Bartolomeo Eustachi, a chart describing the number of roots each molar has (2)

In the realm of dental surgery, understanding of tooth morphology leapt ahead. Bartolomeo Eustachi (1520-1574) published the first full book on dentistry in Europe in 1563, *Libellus de Dentibus*; the vast majority of his book is dedicated to the development and anatomy of human teeth. He was the first to describe the developmental cyst that develops into teeth. His biggest contribution was a refinement of the existing techniques for scaling teeth: he was the first to describe scaling the root

surfaces beneath the gums, using a curette to remove diseased gum tissue from the periodontal pocket, and applying astringent herbs to the site. This is the modern method of treatment for deep periodontal pockets (2).

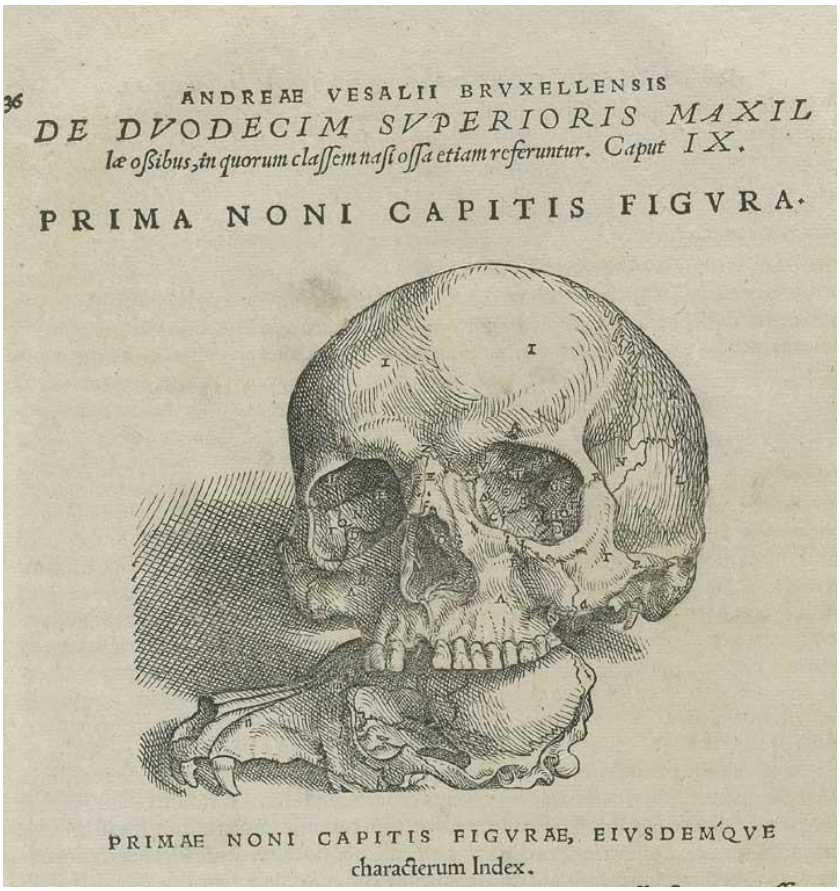


Title page of the Zahnartzney Buchlein, published in 1530, showing a tooth extraction (6)

The greatest mystery of this era is the book called Zahnartzney Buchlein (A Little Book of Dentistry) – this book is referenced in many contemporary texts as well as histories written prior to the 1990s CE but I have been entirely unable to find the book itself. According to Ring and Guerini, it gave the first (and only in-period) instructions for true restorative fillings. Guerini supplies copies and translation of the fifth chapter of the Zahnarzney Buchlein, including these instructions for fillings: ”First, by scraping and cleaning the hole and the carious parts with a fine chisel, knife, or file, or other suitable instrument, as is well known to practitioners, and then by filling the cavity with gold leaves for the preservation of the other portion of the tooth” (6). These instructions are for gold foil fillings which were in use until the early 2000s CE (gold is an excellent material for fillings due to its biocompatibility and the ability to shape it while cold but it finally fell out of favor in the modern era due to cost and the desire for tooth-colored fillings). These instructions call for manually removing the carious tooth structure and replacing it with gold, a process which stops the advancement of caries and restores the tooth structure so that the tooth is made healthy and functional again, unlike previous fillings which did not restore the tooth to full function and did not prevent further decay. Gold fillings were previously mentioned by Giovanni Arcolani in his 1475 text but no instructions were given. Since gold fillings show up out of the blue in European text

(6,7,10), it is my guess that these were originally invented by a barber-surgeon who didn't write a book and they made their way into print later, or that the technique was pioneered in another part of the world and brought to Europe without attribution to the inventors.

In the late 15th century, Paracelsus introduces using sweet oil of vitriol (ether) as a general anesthetic for veterinary surgery. In 1540, Valerius Cordus published *De Artiflciosis Extractionibus* in which he gives the first written instructions for the distillation of ether (1,8). Although ether inhalation is a safe method of inducing temporary unconsciousness (to date there has been no known case of death by ether inhalation), it is extremely flammable. In an era where all artificial light was from open flame this limited its usage and we see no indication that its use became widespread until after the invention of electric lights several centuries later.



Anatomical drawing of the human skull by Andreas Vesalius (10)

Conclusion

We have extensive information about dental treatments in period but the main piece of missing information is how common each treatment was. Because we do not have fully representative selection of skulls across time from any one area, it is difficult to determine how much access to dental care most people had. It is further complicated by the fact that most fillings were made of soft materials that would not likely survive over the centuries.

Further study

For further study I plan to search backwards from the overview articles I have found to the original journal articles, especially in regards to Viking tooth modification. I also plan to read more about Mesoamerican and Indian dental practices.

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