Dentistry in Ancient Egypt

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Abstract

Dentistry, dated in Ancient Egypt as an independent profession since the early 3rd millennium BC, was the first specialty recorded in a document in ancient Egypt, but nothing proves teeth interventions in mummies.

The mouth and dental preservation was very important in rituals and theology because, as a source of exterior speech, it allowed man to express his spiritual feelings. The emphasis put on the mouth, lips, tongue, palate and teeth, was connected with the soul, the expression, and articulation of words. In the 'Opening of the mouth' ceremony, the dead jaws were freed to rebirth, give a voice and utter the words and names of power. Thus the white and healthy child Horus' teeth allow to make up the undamaged mouth (PT 79 a) and five onions, their symbolic representation, were given the dead as a sacred offering.

The emphasis put on the mouth, lips, tongue, palate and teeth, was connected with the soul, the expression, and articulation of words. As source of exterior speech, they allow man to express his spiritual feelings. In the Memphite theology the intellectual God Creator Ptah have generated the world pronouncing their names. Teeth and lips represent the magical verbal action and the tongue means speech, the *logos*.

Dental problems were well known and some indications of doctor's different diagnosis and treatments were found in medical papyri. The most common dental diseases were: attrition, frequent until pulp exposure, receding gums, caries and the destruction of enamel, chronic suppurative periodontitis that causes mobility, dental abscess and sepsis, loose teeth, ulcerative stomatitis, alveolar diseases and heavy deposits of calculus. Egyptian paleopathology and molecular biology provide new medical information and had revolutionized all aspects of dentistry, changing previous beliefs. However Egyptians were creative or witty and had devised many treatments for the various affections, both chirurgical and medicinal in nature, using different drugs.

By studying a critical scrutiny of the development of dentistry profession in ancient times, it has been possible an exploration of dental problems, diseases and treatments and establishing guidelines and difficulties.

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Introduction

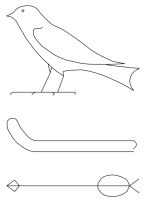
Since the early 20th century, Egyptologists [1] and dentists have debated the existence of an operative dental profession in ancient Egypt, due to the apparent lack of actual surgery to cure these affections. However Herodotus (II, 84) stated that dental physicians existed and written records were found about this profesion as the first medical specialization. On the other hand, P. Ebers, Edwin Smith, Kahun, Hearst and Berlin presented some recipes for dental problems which could have made a difference by alleviating the toothache or even inhibiting inflammation. The method of removing a tooth *nDHy*, according to a late P. Vindob, would be: "*apply the drug aforesaid on the tooth while it is decaying and pull out*" [2]. Since dental extractions are hard to prove, there were, however, verbs denoting the action of falling, filling, removing or pulling out a tooth.

F. Leek denied the excellent preservation of some mummy teeth due to intentional care[3] since nothing proves for him dental interventions in skeletons. Furthermore, although medical papyri contain some prescriptions for dental problems and, undoubtedly, this branch was well known, neither literature nor skeletal material provides convincing evidence about the practical work of that professional, called *ibH(yw)*

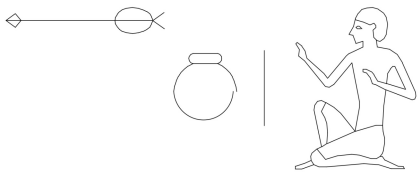
. Nevertheless, few examples of written records included the Egyptian expression *ir n bnr*, 'take outwards'. To some extent, physicians and dentists in Egypt, like in other specialities, often employed an integrated therapy as a normal activity, including spells and other magic rituals along with medicinal practice. Concerning the Edwin Smith papyrus, this medical text, probably a manual of a military surgery with anatomical observations and different diagnosis and treatments, can be considered a pedagogical and scientific catalogue of different cases (*sSAw*). Case 25 describes the treatment for a dislocated jaw, difficult to open, which has not changed over the last five thousand years. The patient's mandible was reduced back in the correct position after placing the fingers inside the mouth and the thumbs under the chin. In short, some of the discovered mummy jaws and skulls have provided a wealth of evidences to complete the text information and it can be said that Egyptian dentists knew at least how to drain an abscess or cut away cankered gums.

Dentistry and symbology

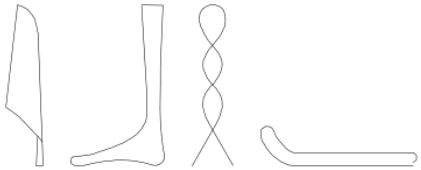
Generally speaking, dentistry is dated as an independent profession, without doubt, since the early 3rd millennium BC. Hesy-Ra (fig. 1), the earliest ever record physician dated ca. 2700 BC., was King Djoser's doctor and Chief of dentists, *wr ibHy swnw*



. Besides, dental interventions in Ancient Egypt prove the existence of an ancient activity[4] in this sense. Egyptian early specializations, quite advanced for ancient standards, had an important development with many ranks in ancient medicine, being dentistry the first known. Although already in the Old Kingdom sources we can find other specialists such as proctologists, called the 'shepherd of the anus' (*nery phuyt*) gastroenterologists with stool examination, ophthalmologists, etc., tooth care was clearly a major problem and its ailments were described in the Ancient Egyptian medical writings. In Pharaonic times, a dentist was considered as one who knew and attempted to cure mouth diseases. The professional name of this type of *swnw*

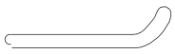


, the common word for doctor, *ibHy* comes from tooth, commonly called *ibH*

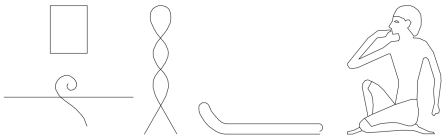


. Its determinative

or

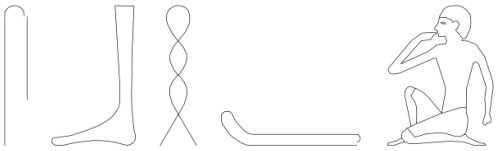


was perhaps represented by the hippopotamus canine or tusk (fig. 2), with a well marked curvature and concavities in the tooth labial surface. In fact the name could also be abbreviated with only the task-sign hieroglyph, as can be seen in the Hesy-Ra's tittle. The verbs related with teeth, such as to bite (*psh*

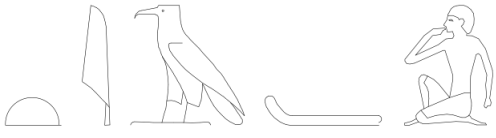


), to laugh (*sbT*

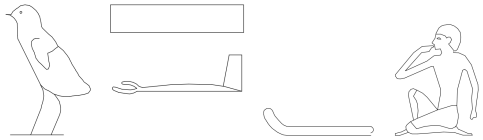
= to show teeth), to shout (*sbH*



), to clench (*tiA*



), to chew (wSa/wgi,



or

), always include this determinative [5].

Fig. 1. Hesy-re, Head of dentists, a third Dynasty physician, from his mastaba at Saqqara, (Reeves, 23)

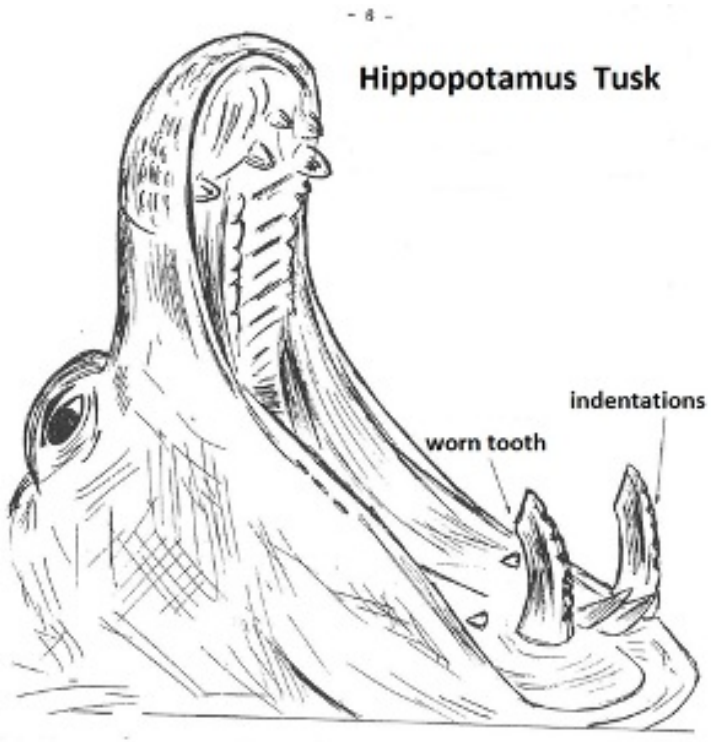
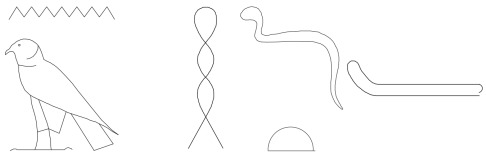
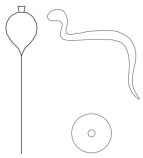


Fig. 2. Hippopotamus tusk (T. Bardinet, *Dents et mâchoires,* fig. 1, 6)

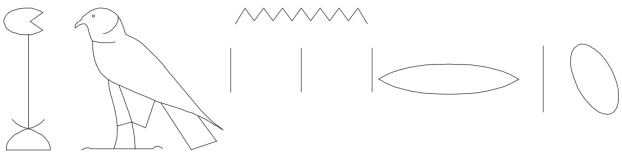
Meanwhile the elephant tusk, canines or the offensive animal croc was named



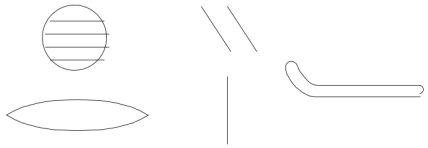
nHDt related with *HD*



, whiteness. However, the tooth like a pick or burin and the offensive animal croc that tears, grinds and shreds, can also receive the same name xl as the late Egyptian noun for a tool made of iron, chisel orxnr

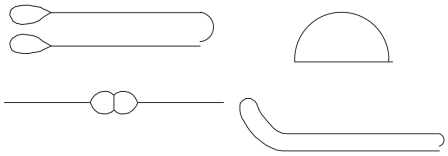


, due to its similar shape coming from the verb root *xll* ‘pierce, bore, hollow out’. *nHDt* or *nDHt* with its equivalent *xl*

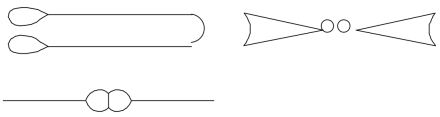


in turn, can also design molars or poison fang, assimilated by their hardness[6].

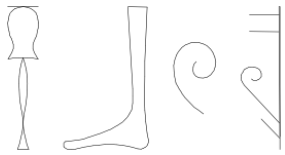
Together with the hair, bones and skin, the set of teeth was a body part in series that received the collective noun *Tst*



, written exactly as the radical of the verb tie *Ts*

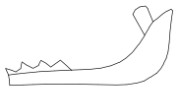


, and that expressed some relation with the verbs laugh and delight and the adjectives beautiful, dazzling and healthy. It was compared with precious materials such as turquoise and with the powerful dandelion while for the animal dents the material was ivory (*Abw* / |

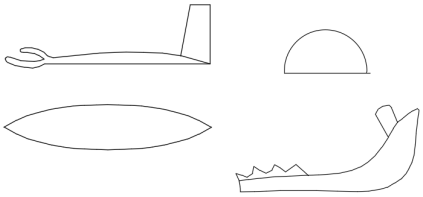


), used also in the Egyptian pharmacopeia[7]. The same radical *Ts* was utilized for the referential meaning of group, company and army.

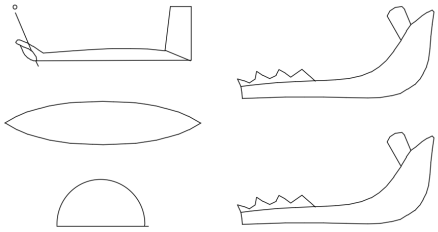
On the other hand, Egyptians only recognized lower jaw bone



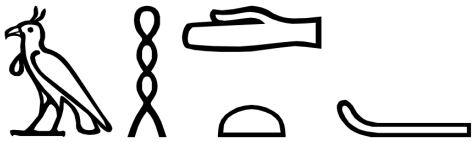
, mobile and active part whose symbol is an ox jaw[8], used as determinative sign at the end, called *art*



in singular, or in dual *arty*



(P. Smith 7, 25). It was fused with the maxilla, divided in two halves but forming a simple anatomical unit important in chewing and called *wgyt* derived from the verb chew (*wgi*). In consequence there are 2 words for the lower jaw used interchangeably and sometimes in the same sentence. The upper jaw or dental typology such as incisors, canines, premolars, molars, did not have a specific name or a phonetic distinction in Egyptian vocabulary [9], except the molars called *nHdt*



. In its turn, the Greek more ancient tooth denomination given by Homer (*Iliad* V, 74; X, 375; *Odyssey* XVIII, 28) was ὀδόντες. However, they emphasized differences between their position (front teeth=incisors, canines) and their function (*τομεῖς*=incisors that cut or *διχαστῆρες*=incisors that divide) but not between premolars and molars called both *γομφίος* [10]. The word *μύλη* expressed a unified concept related to hardness and the verb to grind (Galen II, 753, 12 =Künh *De ossibus et tirones* 5) because they are a type of multiradicular tooth difficult to remove.

In Egypt the mandible, a basic anatomical structure, sometimes called *sXwy*, with the upper maxillary and inferior mandibular arches connected in two opposite semicircles in block, was the place where the circle of dents was positioned. Its vertical part, the ramus, had its own name *amat,* resembling one of both claws of an unknown *ama* bird. The articulation with the temporal bone and the origin and insertion of powerful *temporalis* or temporal muscle, named cord, is well described [11].

The ceremonial linked to the importance of teeth

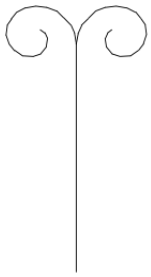
Teeth and the structure of mouth play important roles in the ability to eat and speak and the tongue, which allows us to taste, also helps form speech sounds into words. Studying the Egyptian myths and rituals, especially the 'Opening of the mouth', connected to statue magical animation but later to immortality, we could understand the importance given to the teeth and jaws, vital to eat, speak and even rebirth in other life[12].

In the famous myth of Osiris and Seth[13], the former was locked alive in a beautiful chest, that would fit only him, by his enemy and brother Seth. This sarcophagus was thrown into the water, but Osiris death is only mentioned by inference, 'made disappear' (Diodorus I, 21) when he really was drowned. When his murderer, Seth, discovered and recovered his brother's body, cut it into fourteen pieces, number that could reach forty-two, one for each nome at the end of the New Kingdom legends. He spread them in the swamps (Plutharch, *Isis and Osiris* 18) all over Egypt. Then, the 'second death' of Osiris really happened. Nevertheless, in both contexts the fresh water, equated with Isis's tears or with Osiris body fluids or humors, was always source of life and re-birth (CT 353; 396 a-b). In the same way, vegetation was born from decomposition of humors, being both generating liquids of life with the sperm.

In the earliest mentions of the Pyramid Texts, Isis tried to restore her spouse's body in her second quest, in order to return his integrity. Before being joined (*mab*), the dismembered pieces were gathered (*inq*), amassed (*qat*), united (*dmD*), drawn together (*shm*) connected to each other (*tjs*) culminating in the burial of each part separately or sometimes together. Seth also cut in two the mandible, losing Osiris' jawbone; finally it was found, gathered together and buried in Hierakonpolis, his cult center. In order to survive in the Beyond, it was brought into his face to allow feeding the dead and for his body to function optimally [14].

In the Hellenistic Plutarch's review, comparing with the version of the Pyramid Texts, *'the actual death is accentuated by the reference to the decomposition of the corpse; the destruction of the body by dismemberment, (*practice in use during the predynastic period)" [15]; followed by the body restoration, his birth and the institution of funeral rituals. The dismembered body was needed to the future reset of beings as much as the 'Opening of the mouth' ritual to free the body from the paralyses imposed by death and to be recomposed like an embryo. Still more important, the dead´s jaws were freed to give him a voice, related to the mandible, in this ceremony and made his recitation possible. It was also for reactivating the dead and statues and for making him partake in food offerings, once the journey into light began. The Sem-priest, the most important figure of this ritual (BD 133), touched the mouth and eyes of the statue or mummy and, pressing upon his lips, allowed the deceased to open his mouth and speak.

The *psS-kf* knife'(fig. 3), the 'divided silex' used to make firm (*smn*) the lower jaw, symbolised the maxilla, but its fish-tailed shape was not different from the hieroglyph of bicornuate uterus



. It appeared as a flint knife in the Pre-dynastic times and later became part of the set of these ritual instruments, used also for re-founding the mouth movement again. Once his lips had been open by the Sem priest, the deceased would participate in a number of revivifying ceremonies. He would, for example, eat a replica of the white Eye of Horus cake to attain immortality, because it was a symbol of healing. With magically freed jaws, having been given a mouth, the deceased was also provided with the *hekau* or words of power [16] and the ability to utter them correctly.

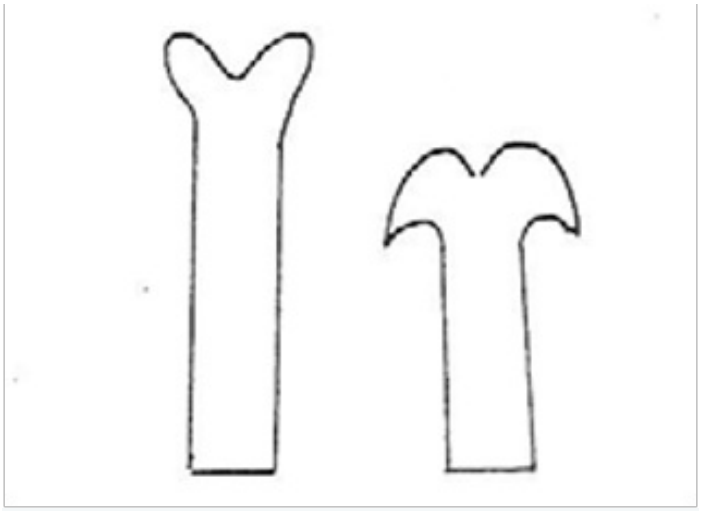
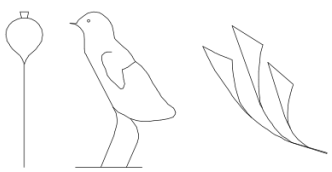
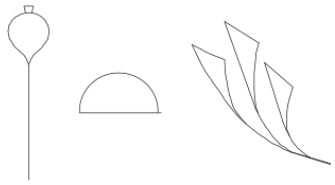


Fig. 3. Two examples of *psS-kf* knife' from the Old Kingdom (T. Bardinet, *Dents et mâchoires,* fig. 2, 111)

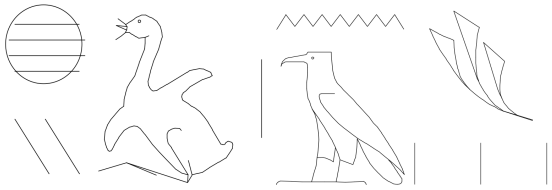
To clean and purify the deceased's face and mouth, onions, named



HDw or



HDt, frequently confused with the garlic-*xTn*



[17], were used as solar rebirth and deification instruments. Five of them, symbol of the child Horus pure teeth and assimilated to him, already in the Pyramid Texts (35a, 79a-b), were found in a bowl at the tables of offering associated to the ‘Opening of the mouth’ ritual, where formulas related mainly with onions and the Horus tooth’s legend should be recited. Each corresponded to one of the orifices to be opened, two eyes, two ears and the mouth [18]. Given to the dead as a sacred offering (PT 35a) they corresponded to five types of milk set of teeth: central and lateral incisors, canine, first and second milk molars.

Another myth about the Horus baby milk teeth give us many common meanings about onions, interchangeable with the white Eye of Horus and replaced later. It reveals that the origin of the onion was his milk teeth that fell to the ground and then begot under soil like the Egyptian walking onion bulbs (*Allium cepa proliferum*) (fig. 4). A cluster of bulblets or ‘topsets’ appeared at the plant top encased in a capsule like garlic instead of flowers (fig. 5). Once open, these bulblets fell off and begot also under soil [19]. In the same way the white Eye of Horus which comes from the land would hint at this white onion which sprang from soil. The eye and the tooth of Horus were thus interchangeable. Stems of onions were offered to the deceased and the Sokar deity in the month of Khoiak[20]. Thus, the white and healthy teeth of Horus allowed making up the intact mouth (PT 79 a).

Fig. 4. Egyptian walking onion (*Allium cepa proliferum*)

Fig. 5. Bulblets or 'topsets' that sprout in a capsule like garlic

On the other hand, it is worth highlighting the importance given to the mouth, lips, tongue, palate and teeth; they had supremacy over all other members and became sacred, because they had the power to describe what the heart conceived as oral communication and to express all the ideas connected with the soul and mind (Urk I. 38). Mouth gives form to voice and allowed revealing towards the exterior through the speech, feelings, emotions, sensations and reflexions and, in this way, man's attempt to express materially what he feels spiritually. Also deity could create the world through the mouth and the words [21]. In the Memphite theology[22], everything is first thought of or planned in the heart of the creator-god. What originated in the heart is only completed by being given their names, since the names appeal their reality or their identity. Thus the intellectual God Creator Ptah pronounced the names and put in place all things in the world [23]. In this anatomical myth about creation setting through the senses, Ptah with his sighted eyes, listener ears, sniffing noses, created the world, its inhabitants and the other gods, *kas* or spirits [24]. The Heliopolitan Enneade of Gods was also included in this cosmogony as well as the primeval Hermopolitan Ogdoad, incorporating the god Atum who created with his semen, lips and hands [25], being the lips the only body part which both theologies have in common[26].

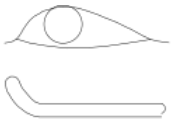
Tongue means speech, or in the later philosophical and logical meaning,*logos*. God's heart, center of decisions, had thought (knowledge faculty=*Sia*) [27] and his tongue and mouth had created through words. He gave rise to all thing qualities through the Desire of his heart and the word of his tongue [28]. The efficient words in the royal proclamation (*Hw*) (CT IV, 145) which were in the mouth (*tpy-rA*), had a magic power if the message was perfectly heard and articulated, controlling the different organs of the mouth. The sacred anatomy played a particular role in phonetics and language articulation and teeth and lips represented the magical verbal action for the creation by the word [29].

In the Greek world, a similar assessment was made by Democritus: "*the tongue, mother of the speech, messenger of the soul, portal of taste, is guarded by the powerful teeth barrier, serving the speech as a dubious path to rational or irrational... The chin, in the shape of a turtle, accepted a number of teeth, like nails. The lips, forming a soft outline around the mouth, provide a governing of proper word and a correct articulation… The multiple channels of the lungs are crossed by the air to create the spirit, cause of the voice*" (letter send to Hippocrates) [30].

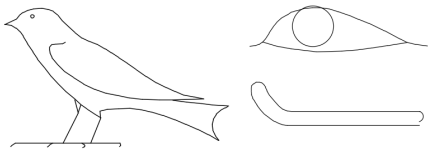
Dental profession and analysis methods

Being an independent profession, it might have never been prominent, although the human teeth were an essential source of benefits because they collected food, sustained the body and in an intellectual level they were useful to properly express thoughts. All strength and clarity were lost without them. It is strange that the title 'dentist' having been used since the Old Kingdom and medical papyri mentioning treatments since the Middle Kingdom, there is no evidence that technical skills were developed as in other fields to alleviate pain and to restore function and appearances of devastated dentition. Perhaps the scope of the term is misinterpreted and it refers to someone subordinate to the doctor.

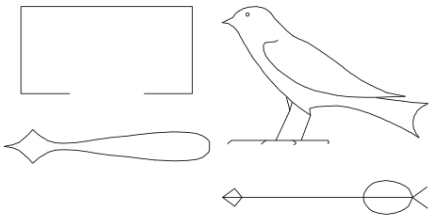
Of the 7 known titles, 6 belong to the Old Kingdom and only one is from the Late Period, from the XXVI Dynasty, which suggests that the term was not used for 1,700 years unless new indications appear [31]. Apart from Hesy-ra, the first recorded Egyptian dentist and physician, famous for his tomb paintings and cedar wood paneling, we know other swnw who were also Iry ibh



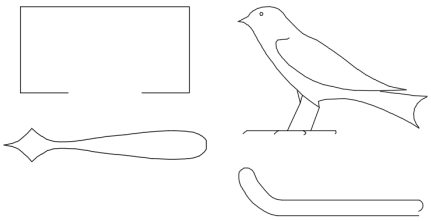
, that means 'who deals with teeth', title used in their inscriptions:*Khuwy*, Chief of Dentist (wr irwy ibH(w),



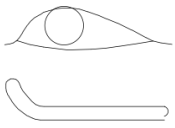
and Chief Palace Physician (wr swnw pr-aA



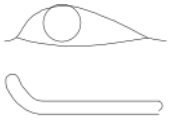
) in the Old Kingdom [32]; *Ni-ankh-Sekhmet*, chief of the Dentists of Palace (wr ibHyw pr-aA/



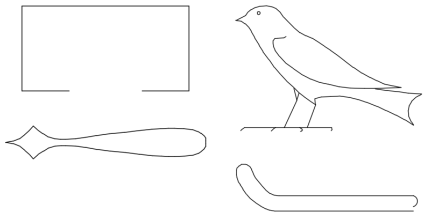
), and it is supposed that he was the first rhinologist in the history of the Otorhinolaryngology area dedicated to the nose who appears in the same stele as *Menkaureankh* (iry ibH(w)/



, only dentist in the Fifth Dynasty; *Neferiretes*, who has only his name and principal title (iry ibH(w)/

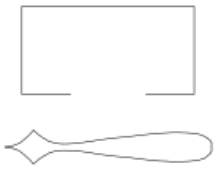


; and *Psammetike seneb*, Chief of Dentists of the Palace (wr ibH(yw) pr-aA/



) in the Twenty-sixth Dynasty[33].

The palace (*pr-aA*



or great home) was the principal centre of medical studies and prestigious activities related with outside medicine, being its physicians recruited from the best outdoor medical practitioners. It is obvious that the traditional medical-type organization continued until the Late Period when the House of Life of Saïs was newly reorganized [34]. A Palace master of dentist was a specialist with particular knowledge and able to conceive specific remedies to specific diseases as was Hesy-re and others. He achieved the highest hierarchical ranking in his speciality, searching remedies and pathological correlations for mouth and teeth diseases. These therapeutic discoveries were, of course, followed and applied by all other doctors in the country [35]. In ancient times, the dental sickness with toothache and degradation, were part of the hidden and internal diseases, difficult to explain and to predict a solution. It was only atteinted through speculation because, unfortunately, there were no tools to accurately determine causes, and thus they seemed to escape a correct analysis [36].

Nevertheless, the current studies in Egyptian paleopathology provide now a substantial amount of medical information insomuch they have revolutionized all aspects of dentestry. As a disease science that studies ancient corpses, it is based on bones, using for their own ends complementary examinations in a number of important pieces well chronologically distributed. Teeth and jaws were highly resistant to decay, especially in the dry conditions of Egypt and unlike soft tissues, they were generally undamaged by the mummification process. Dental anthropology studies tooth condition in a perspective beyond clinical science using modern science and technology. The royal mummies were X-rayed by orthodontists from Michigan and Alexandria Universities and subjected to superimposed cephalometric computer tracing [37]. Radiography today shows details which are hardly inferior to those obtained with living patients. Previously in 1912, E. Smith had found that the Ramesses II's teeth, who lived 93 years, were clean and in excellent state of

preservation. Nevertheless, X-rays revealed that he was dentally disabled suffering missing teeth, for severe attrition, exposure of pulp chambers and roots, loss of bony support and periapical abscess [38].

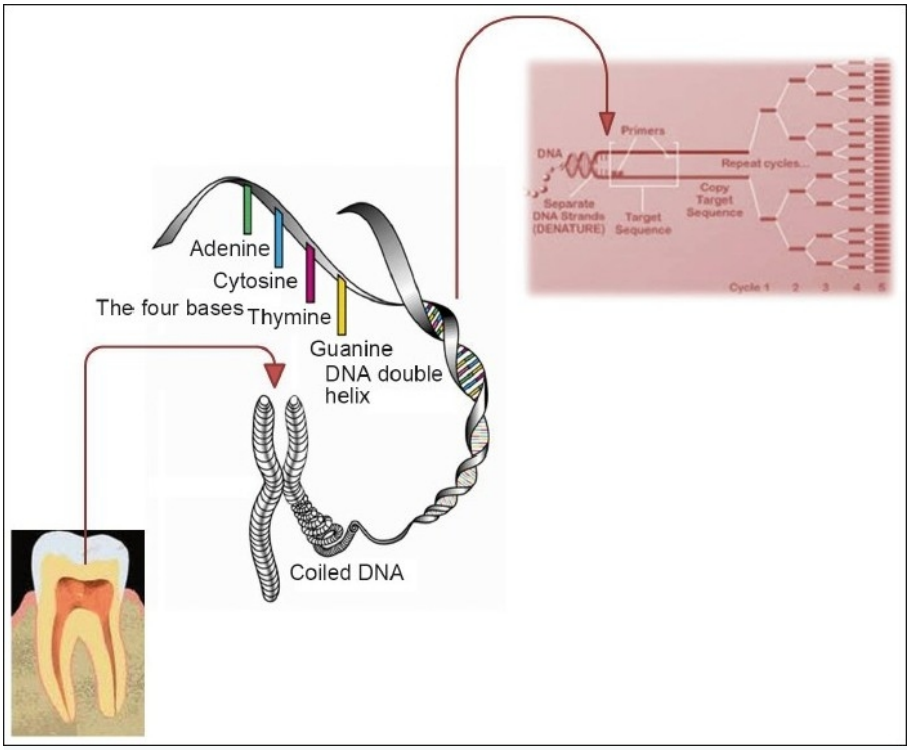


Fig. 6. Schematic photograph showing replication of DNA by PCR (K.L. Girish and al., "An examination of the dental state…", fig. 1)

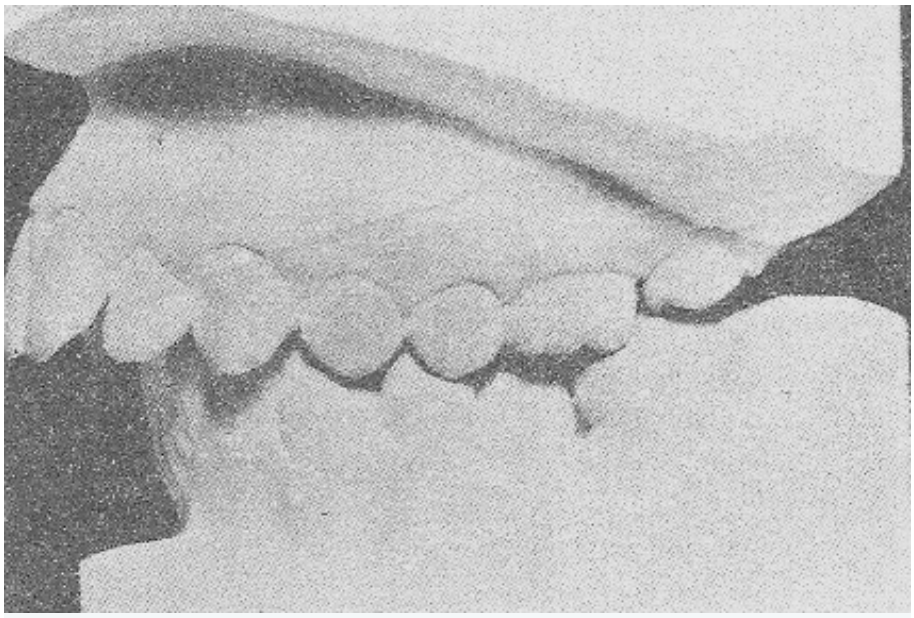


Fig. 7. A child with maloclusion (Prognathic maxilla) (Ebeid, *Egyptian medicine in the days,* 342)

The recent advantages in Egyptian paleopathology molecular biology provide now a substantial amount of medical

information that has revolutionized all aspects of dentistry. DNA fingerprinting (fig 6) is a tool used to unravel the mysteries associated with the oral cavity and its manifestations during disease conditions. As dental pulp is surrounded by dentil and enamel, which forms a dental armor, it offers the best source of DNA for reliable genetic type in forensic science [39]. The diagnosis and interpretations of dental disease from ancient remains are able to provide indicators of population general health as well as furnishing information about diet, oral hygiene, environment, lifestyle and prevailing economic conditions. By the teeth, family relationships could be evaluated and it has been proved the considerable heterogeneity of New Kingdom pharaohs. Tutmosis I, displaying 'bi-maxillary protrusion' as his successors Tutmosis II and III, but it is not the case of Tutmosis IV. It was explained because princesses from many conquered nations were accepted as potential consorts while in Giza the nobles of Old Kingdom were quite homogeneous.

Maxillary prognathism is connected with Nubian people[40] due to their oral habits such as thumb sucking or pushing the tongue forward that resulted in markedly protruding upper teeth known as 'buck teeth' (fig. 7). J. Harris observed this malocclusion type and facial appearance perhaps as hereditary or environmental [41].

Studies of several thousand ancient Egyptian skulls from museums in Cairo, Cambridge, London, Manchester and Turin have also recorded some non-pathological dental abnormalities such as impacted third molars, retained deciduous teeth, incisors crowding as well as examples of displaced, transposed, rotated and tilted teeth [42].

Dental diseases in ancient Egypt

Ancient Egyptians were not safe from oral ailments. Their diet, full of coarse fibres and often uncooked vegetables, added to a poor dental hygiene, caused various diseases such as attrition, the most common, caries, periodontitis and heavy deposits of calculus (fig. 8). The incidence of caries versus pyorrhea and attrition, common in early times, varied according to the area, the times and the social class but later, with improved food technology, these trends were reversed. At 4000 BC the greatest change in nutrition occurs when the inhabitants of the Nile become farmers and herders leaving the habits of hunter-gatherers [43]. This produced an increase in carbohydrates and a decrease in protein, which caused a reduction in height in communities fed a cereal diet [44]. On the other hand, many of the Egyptian citizens' problems were caused by the environment. Sand blown by the wind caused lung and breathing disease and eating daily grains of sand mixed into food, especially bread, resulted in an additional element of abrasion and wore down people's teeth, causing tooth decay and abscesses [45]. For instance, ground corn with stone grain in their bread contained sand husks, even inorganic particles of rocks [46], predominately quartz with presence of some feldespar, mica, and others. Additionally, grinding the grain with soft sandstone implements (fig. 9) and baking the bread on outside stone ovens would have also contributed to contamination.

Fig. 8. Egyptian skull c.1500 BC, Dutchworth Collection Cambridge University, Showing tooth, wear, pulpar exposure, caries (R. Forshaw, Forshaw, *Dental health*…, fig. 2)

Fig. 9. Tomb model showing a woman grinding corn in a mortar (R. *Dental health*…, fig. 1)

Attrition, caused by tooth-to-tooth contact, resulting in loss of tooth tissue frequently until pulp exposure, was aggravated by coarse diet high in abrasives, having lacked necessary vitamins and minerals. Skulls and jaws found in burials and tombs show this kind of disease to some extent, being a very prominent feature found in nearly each of the forty skulls from the late period (approximately 1069-715 BC) [47]. Leek, in a study of 4800 ancient Egyptian teeth, found that nearly 90% of the teeth showed some evidence of tooth wear. It increased with the age and varied from a slight polishing of the cusps to almost complete loss of crown structure.

F. Leek [48] proposes four different types of attrition to describe this progression (fig. 10). The first case shows asymptomatic flattening of the enamel cusps. In the second case dentine was exposed and probably associated with

some discomfort. In third type, the abrasion rate of primary dentine often exceeded the deposition rate of secondary dentine and the pulp cavity was exposed as well as the nerves, provoking discomfort to mechanical, thermal and osmotic stimuli, being these two last processes common between Twelfth and Twenty-fifth Dynasty mummies. Finally, the forth type denoted advanced wear of the tooth body. Teeth condition, at first very poor, showed a steady decrease and the incidence of worn teeth was noted between 4000 to 1000 BC, probably due to improved grain grinding techniques [49].

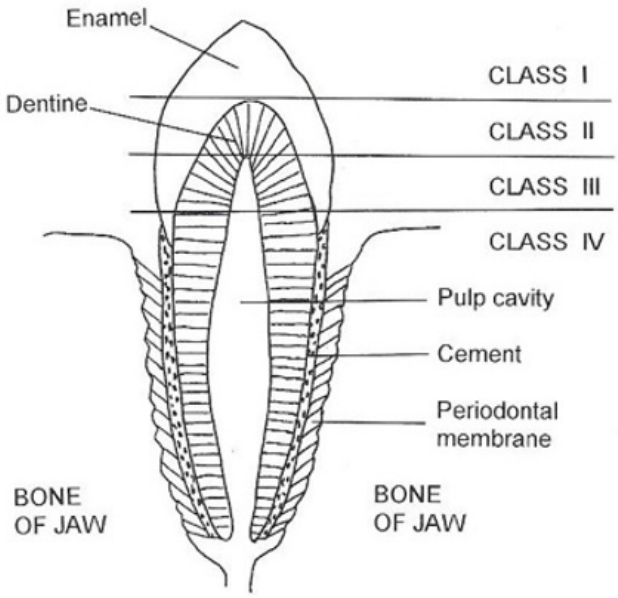


Fig. 10. Internal structure of a tooth with Leek's classification. Classes III and IV would have produced considerable pain (J. Nunn, *Ancient Egyptian medicine*, p. 203)

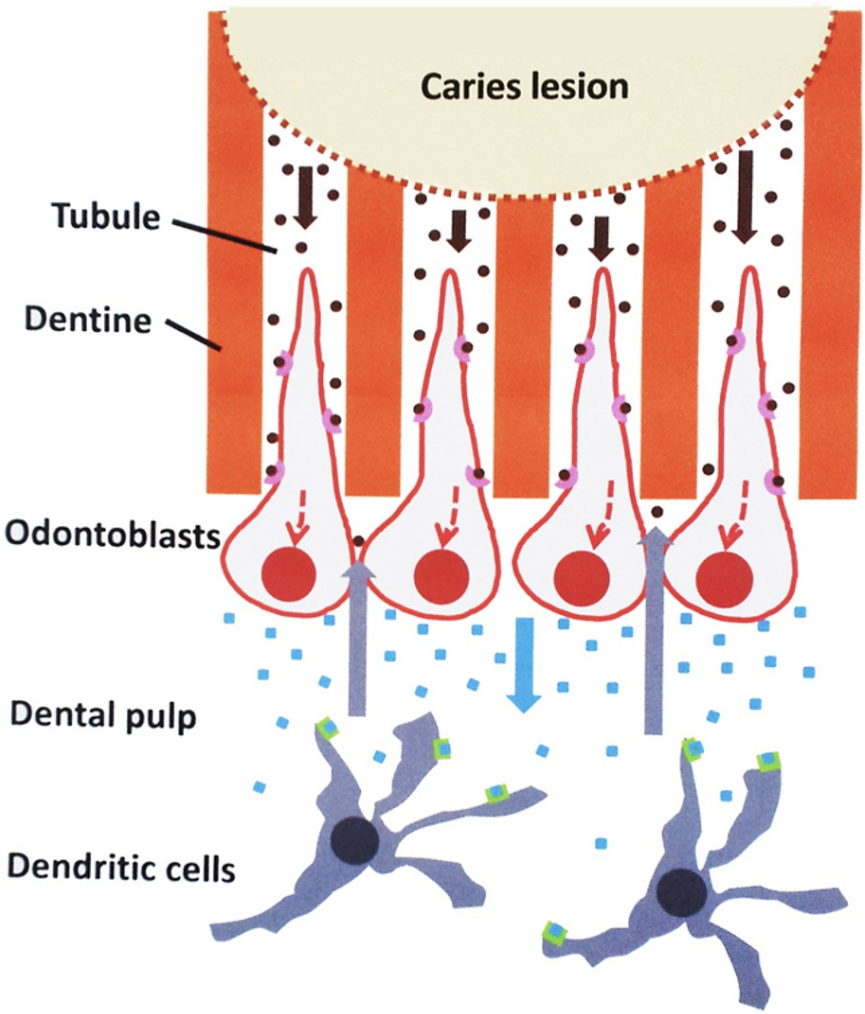


Fig. 11. Odontoblasts and pulpal exposure

Attrition was not a serious disease, but left unchecked, could cause much more severe issues such as abscesses, gum and jawbone inflammation and tooth loss. It was often so extensive than the odontoblasts, forming dentine and forced closer togheter, were able to lay down secondary dentine, resulting in pulpal exposure (fig. 11), necrosis of the pulp and subsequent apical infection [50]. A possible later consequence of this infection was cystic formation, epithelial residues or sac in the periodontal ligament as a result of inflammation, a phenomenon observed in some skulls (fig. 12). Additionally, osteomyelitis (fig. 13), an infection of the bone tissue caused by microorganisms and probably not uncommon, could have been a potential lethal lesion because of its frequently associated untreated bacteraemia, for Langsjoen responsible for many deaths in Antiquity [51]. The extreme wear on top of teeth and between them (interproximally) was also common among Egyptians. When food particles were jammed between them, they forced into the roots leading to decay and dental abscess.

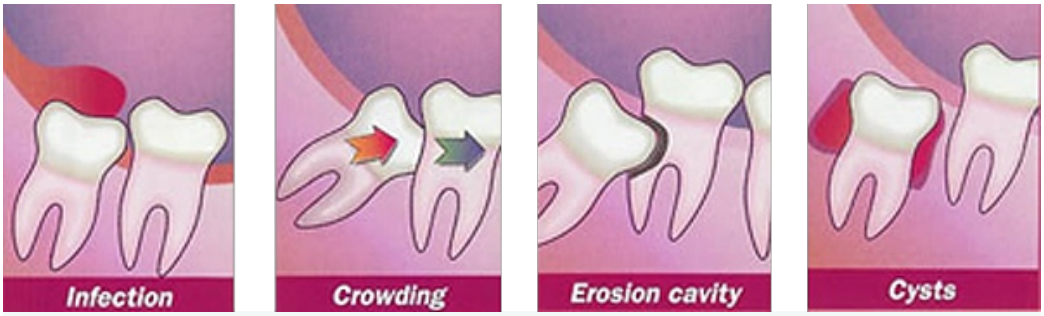


Fig. 12. Infection and cystic formation. Care dental

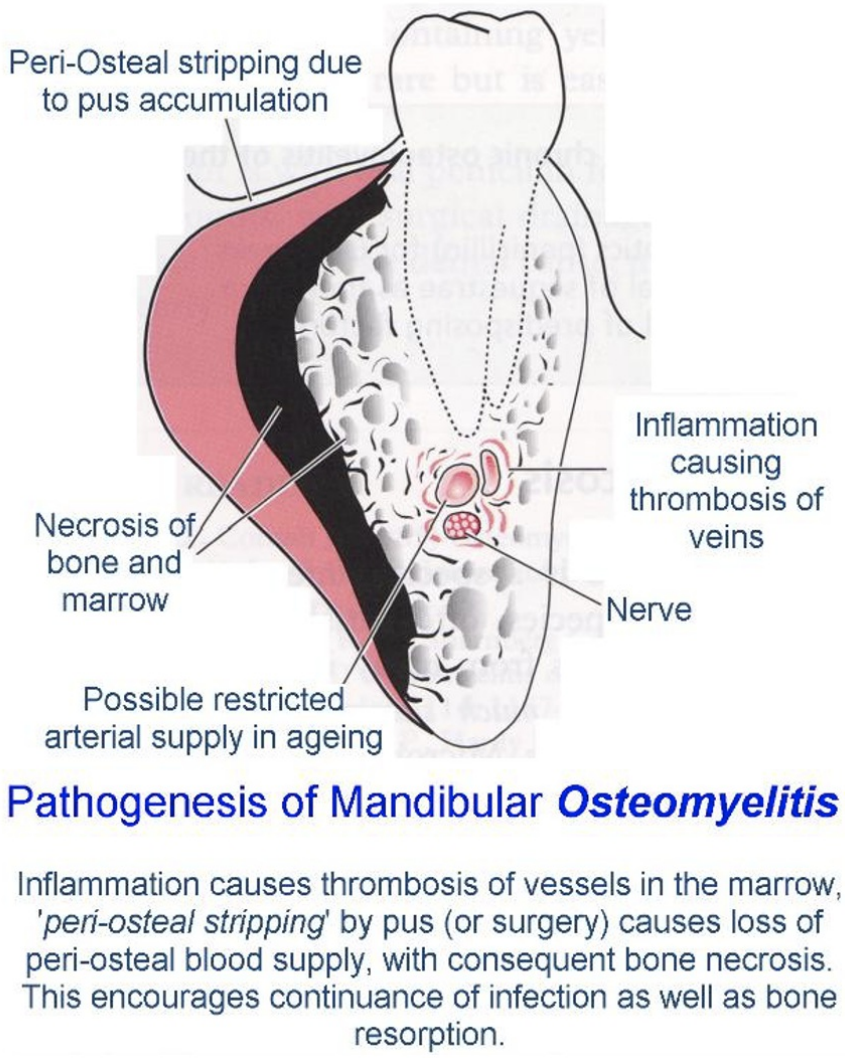


Fig. 13. Osteomyelitis and necrosis of bone

Regarding **caries**, cavities in teeth caused by bacteria that form acids in presence of sucrose and other sugars, all investigators reported their remarkably low incidence in Egypt, extending from the earliest times until the first millennium [52]. However, caries and enamel destruction caused by a bacterial infection called *Streptococcus mutans* produces fractures in the bones, early tooth loss and possibly kills it as well. Despite the lack of fermentable carbohydrates in diet but with fibrous abrasive food, which tended to inhibit plaque retention on tooth surface and also to

eliminate pits and fissures [53], bacteria in dental plaque were still fairly well represented amongst Egyptians. Residual dental plaque due to a carbohydrate diet decalcified the enamel and formed a cavity and allowed the entry of bacteria that attacked the pulp. In the Predynastic Period there were more root caries but in later periods there is a greater amount of interstitial caries due to an increase in sucrose. In addition, beet and cane refined sugar was unknown in that society. These diseases seemed to have been much more common among the elite than among lower classes because the well-to-do gentry, whose food was more refined and had higher sugar content, seemed to have suffered more from caries than the poor. Honey, a major sweet factor, was available but was too scarce and expensive and it had a wider use as external and internal medicament or as vehicle. It has powerful anti-bacterial and anti-fungal properties due to the osmotic effect of high concentrations of sugars, mainly glucose and fructose, and bacteria do not grow in honey. Another factor in preventing dental problems and caries [54] was tetracycline antibiotics formed in brewing processes as a result of contamination with an airborne streptomyces bacteria in food or beer, used to treat gum diseases. During Ptolemaic and Roman times, the incidence of caries appears to have grown among the population at large scale and reached high levels in the Christian era, possibly due to an increased consumption of sweeteners, but the level of tooth wear decreased, perhaps thanks to the better sieving. It seems likely that the increase of foreign influence led to dietary changes which encouraged caries formation [55]. When Hellenistic rulers arrived in the fourth century, food items as fine as white bread, honey and dates, previously not consumed by most of the population, became more readily available. As a result of the increased levels of fermentable carbohydrates in this particular foodstuff, caries incidence rose.

The concept of caries as an internal worm gnawing a tooth (P. Anastasi IV) caused caries, was also adopted by Scribonius Largus, Galen, Avicena (*Cannon* III, 7) and others, possibly as a special case of a much broader theory of *wHdw*, waste products or putrefying feces, considered a special case related to the theory of, evoking the old cosmological concept of spontaneous generation in marshes. They could enter the bloodstream and infect the heart and organs causing disease, one manifestation of which was dental disease. The pus was considered a coagulation of the blood that wore away the tooth (Eb. 89). This injury was sometimes irreversible without attempting reconstruction. Dental fillings made of resin and chrysocolla, a greenish mineral containing copper, for the treatment of tooth decay, show an effort to retain the piece, an Egyptian approach relatively modern using amalgam, considering primarily pathological facts.

Tomb	Title	Sex	Age	Reign (BC)
KV35	Pharaoh	M	50-ish	1388 - 1351

Father	Mother	Spouse(s)
Thutmose IV	Mutemwiya	Tiye

Sons	Daughters	Siblings
Akhenaten, Djhutmose, Smenkhkare(?)	KV25YL, Sitamun, Iset, Nebetah, Beketaten, Henuttaneb	Siatum(?), Amenemhat, Tiaa, Amenemhat, tentamun, Petepihu

Fig. 14. Mummy of Amenhotep III. He has lost some of this front teeth due to the albveolar abcsesses (Elliot Smith [56], plate XXXV).

Dental abscesses (purulence in the gums) (fig. 14) arose from caries or through the pulp exposed by attrition and deep and painful cavities were associated with the exposure of the pulp chamber. Moreover, numbers of skulls show multiple abscess formation, indicative of how severe the tooth wear problem was. A root infection would have been difficult to treat and the hole found in an Old Kingdom mummy could have been a natural sinus. But there would be evidence of the drainage of abscesses through holes using a drill with fire for cauterization, according to Breasted [57], although for Leek [58] it was not necessary to use an instrument because the expansion of the pus, under pressure, forms a sinus and perforates the bone of the alveolus [59]. If it was drilled, perhaps with available techniques, it would have been extremely painful and therefore very difficult to accomplish. But the operation had been a current practice because Leek found twenty-five abscesses in six mummies out of a total of eighteen examined.

Periodontal disease (fig. 15), gum inflamation due to pathogenic microorganism, was also known in Antiquity[60]. It ranges from the mildest stage, gingivitis, to severe state or chronic periodontitis or pyorrhea. Evidence of this chronic illness was recorded in the army of the Greek general Xenophon in 400 BC and also appeared in ancient Egypt. The primary cause of this sickness is today and probably before bacterial irritation brought about by the accumulation of plaque at the dentogingival junction. Plaque begins to mineralize from calcium phosphate in saliva when the pH is alkaline. These form calculi near the submandibular salivary gland next to the parotid gland duct. First, acute inflammation occurs as vasodilation, exuding a fluid with polymorphs and immunoglobulins or antibodies in the fissure between the gingival tissue and the tooth, which could help control the effects of the infection [61]. But the result could be destruction of the gingiva-enamel junction with gingival plaque deposits and then apical movement and loss of supporting bone. In the skulls studied, 2 types of losses are noted: horizontal, which can be confused with the continuous erosion of the tooth, and vertical, which leads to destruction. Although it has to be identified with care and in order not to commit mistakes it is better to use, as a more positive indicator, the appearance of pitting on the alveolar bone caused by the resorption of the outer cortical plate, which then reveals the underlying porous cancellous structure.

Foodstuffs containing sugars and carbohydrates promote a rapid plaque growth. Vitamin D and C deficiency produces swelling and bleeding of the gums and so may result in gingivitis widespread. Additionally, local and systematic agents are known to have influenced the progress of this illness, such as anaemia, diabetes mellitus and tuberculosis; all of these could have caused gingival destruction and bone loss [62]. Also drought and famine, which would have resulted in nutritional deficiencies, were factors that potentially affected the status of the periodontal tissues.

Suppurative periodontitis (blood-eating) was a common chronic inflammatory disease, leading to the loss of alveolar supporting bone. If it progressed, teeth become loose and either fall out or could be removed with minimal effort. Periodontal sickness involves progressive loss of alveolar bone around the teeth and causes mobility and dental extraction: a healthy tooth leaves healthy bones and requires good oral hygiene well healed while tooth loss leaves a post-mortem cavity. Not only periodontal disease resulted in tooth loss, but more likely to be a combination of calculus formation causing some weakened bony support associated with excessive tooth wear and periapical infection. The examples are few, perhaps because the life expectancy average was only about 35 years [63] and the risk of periodontal disease increased with age, having found some more in the prosthetic reconstructions. The abrasive material which

caused attrition should have stimulated the gums and removed hard tartar, both factors against periodontal pathology[64].

Dental conditions were not to be taken lightly: they can very well prove fatal or lethal if they remained untreated. Thus a musician from Thebes, Djedmaatesankh, died around the age of thirty five from extensive dental disease and a large infected cyst. But also death may be the result of a lion, snake or human bite [65], because these teeth are also very dangerous.

There is evidence of other oral conditions such as:**loose teeth, dental sepsis and calculus, alveolar diseases, receding gums** (a tooth which gnaws against an opening in the flesh),**ulcerative stomatitis** (eating ulcer in the gums), **ostheoarthritis** of the temporomandibular joint which is a recurrent finding in many skulls[66]. Ten out of twenty-eight cases were attributed to altered mechanical function of the joint brought about excessive tooth wear, which in some cases had resulted in a loss of vertical dimension. But it is difficult to prove a direct relationship between them [67].

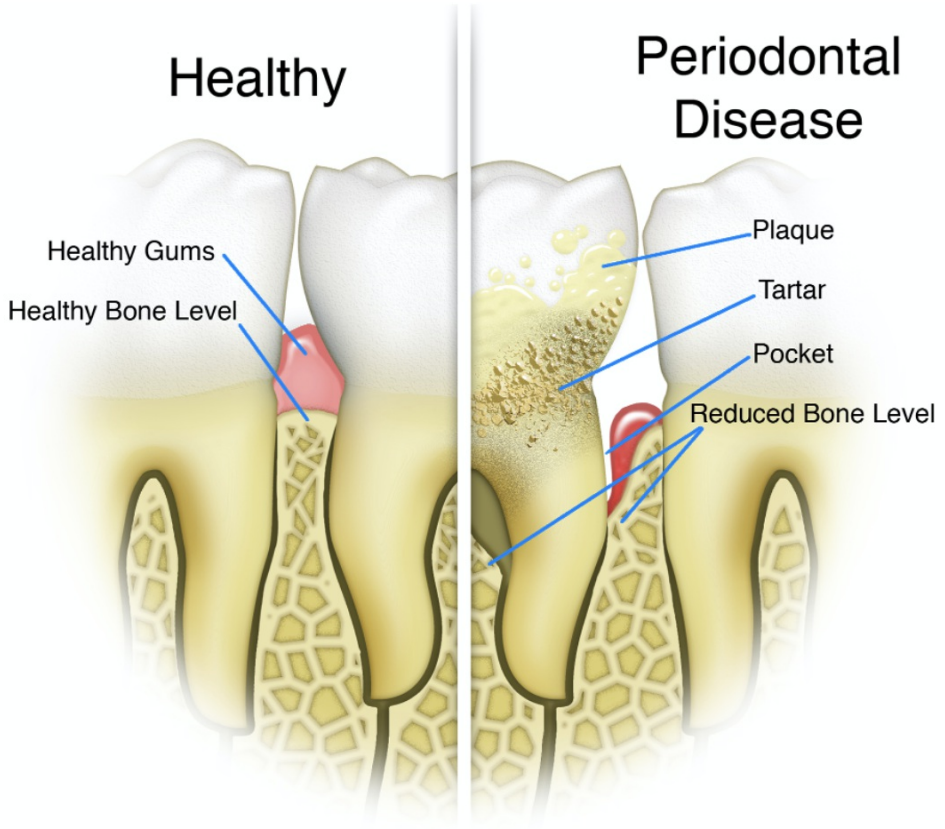


Fig. 15. Periodontal Disease

Fig. 16. Enamel hypoplasia indicated by the horizontal grooves on the teeth. Ancient Egyptian mandible 1500 BC, Duckwort collection, Cambridge University, (Forshaw, *Dental healthand disease,* fig. 3)

The most frequent cause of **enamel hypoplasia** (fig. 16), often displayed as a limited band arranged around the tooth circumference, with a high incidence in children of 3-5 years-old, was malnutrition or a defective diet, but other factors could have been implicated such as major infections, newborn hemolytic disease, vitamin deficiencies and dietary stress.

Cures and tooth treatments

Ancient Egyptians were very attached to their pearly white teeth, and took great care to cure their known diseases as best as they could. They were skilled and inventive in medicine and surgery, relying on actual treatment just as much or perhaps even more than they did on magic spells and prayers to the gods. They had devised many treatments for the various affections, both surgical and medicinal in nature. Drugs were used against a pathogenic principle, and pharmacology was a very complex science based on an accurate observation. This etiological framework related each disease with a medical explanatory theory about internal morbid substances and, following an earlier tradition, Egyptians elaborated a corpus of useful drugs and recipes adapted to each case. But regarding dentistry, there is not enough evidence in the human remains to show that dental surgery was performed or teeth were held with some special technique, as was proposed by Dawson [68] in 1929 and Leek [69] in 1984.

Of the ten medical papyri that have been discovered [70], only five contain dental prescriptions: the Kahun [71] (ca. 1825 BC) which includes two cases, the first references to teeth; the Edwin Smith Papyrus (ca. 1550 BC) which it is a surgical treatise with 2 interesting cases; the Ebers Papyrus [72] (ca. 1534 BC), preferably pharmacological whose prescriptions are repeated in the Berlin Papyrus [73] (ca. 1200 BC) and the Hearst Papyrus [74] (ca. 1450 BC) with a prescription to consolidate an unstable tooth. One may add to the list, the Rylands Papyrus of Manchester [75], not strictly medical, with a fragmentary prescription for a dental powder [76].

Herbs played a major part in Egyptian medicine. Medicinal plants mentioned in P. Ebers included opium, cannabis, myrrh, frankincense, fennel, cassia, senna, thyme, henna, juniper, aloe, linseed and castor oil, though some of them have an uncertain translation. Many vegetals were steeped in wine which was then drunk as an oral medicine. Concerning dental pharmacology, as we have seen, honey was very important either as therapeutic substance or as excipient or bonding element.

Cloves of garlic have been found in Egyptian burial sites, including Tutankhamen's tomb and in the sacred underground bull temple in Saqqara. Egyptians thought garlic and onions aided endurance, and large quantities were consumed. Onions (*XDw*) helped to clean the mouth and was used against digestive system problems (Ebers 192). Raw garlic, an important healing agent then, just as it is still among modern Egyptians and most of the Mediterranean people, was routinely given to asthmatic and those suffering from bronchial-pulmonary complaints, although little has been written about its use[77]. Taken internally or applied externally, wrapped in muslin or cheesecloth, it is now beneficial for bronchial and lung complaints including colds or influenza and protects against infectious diseases. Fresh cloves are even peeled, mashed and macerated in a vinegar and water mixture and was used to gargle or rinse the mouth or ingested internally to treat sore throats and toothache. Another way used both for prevention and treatment is to macerate the cloves in olive oil.

About teeth, it can be found 742 remedies and 11 recipes which pertain to oral issues in P. Ebers (553-555; 739-749). 45% of all dental prescriptions were devoted to the treatment of loose teeth [78]. Four of them are remedies for this problem, using a splint to keep them in place. They were packed or filled with a mixture, akin to a modern composite filling: a filler agent (ground barley) was mixed with a liquid matrix (honey) and an antiseptic agent (yellow ochre).

Eb. 739-749 show gingival pathology (Eb 745) with dental mobility (Eb 748) and sensitive teeth. Five remedies tried to make them firm or strengthen them. Ebers 739 and 743 used the causative verb *smn* with a well attested meaning of make 'firm', 'make fast', 'make to endure' and so on, while Eb. 748 used the causative verb *srwD* that means to 'strengthen' or 'make secure'. Eb. 740 also recommended stopping teeth with resin, chrysocolla or 'Nubian' earth. Grapow (VII, 1, 222) and Lefèbvre translated the word awsA as *ausstopfen* and *plombage,* respectively. Besides others that mean 'to chew' or 'to be given to', it certainly carried this specific meaning, but it is unclear if the cured tooth was loose due to the periodontal disease or was crumbling from caries or by decay. The remedies include scrapings or a milestone (a symphatetic remedy), honey, ochre, emmer seeds and malachite had a favorable effect in the case of sepsis. "*Beginning of the remedies to consolidate a tooth; flour of emmer seeds, ochre, honey, made into a mass, and the tooth to be fattened therewith"* (Eb. 739).

The rarity of sweeteners delayed adverse effects of cavities that were few. When the abscess appears and the infection spread, the best sufferers could hope for was the quick loss of the tooth. There are little indications of an oral hygiene regime in Ancient Egypt and many skulls show considerable deposits of calculus. Nothing resembling a toothbrush has ever been discovered. The only possible aid to oral hygiene known was chewers or masticatories, probably used to refresh the mouth [79]. Priests are known to have chewed natron pellets as a purification ritual[80] and "*the general population is, on occasions, thought to have done so before a meal*" [81]. Possibly some form of wooden tooth pick may

have been used for oral hygiene purposes, since other civilizations in antiquity used similar implements such as chew sticks, tree twigs, bird feathers, animal bones and porcupine quills. Perhaps something resembling a *miswak*, which is a twig of *Salvadora persica* tree whose ends have been frayed, may have been utilized, because Muslims used this centuries ago and continue today for oral care.

Egyptians had various mouthwashes for chronic suppurative periodontitis and common mixtures that had to be chewed and then spat out; they were meant to combat gum infections. *"Another to treat the gums by rinsing of the mouth: bran, sweet beer, Swt Dhwti are chewed and spat out*" (Eb 741). Some had more active ingredients than others, sweet beer, creeping cinquefoil, brand and celery in different compositions, and they seemed to have at least provided the patient with some kind of pain relief. The specific purpose of other mouthwashes was to maintain a healthy mouth and teeth, being known, for Leek, only gargles and local applications.

Great care was taken to avoid *halitosis,* product of mouth *wxdw* and stomatitis (Eb. 122; Bln 35). It must have been troublesome, especially for husbands. To remedy it, Eb 853 proposed chewing balls of myrrh, pignon, frankincense, rush-nut, cinnamon, calamus aromaticus, turpentine resin, sycamore, unknown plants and honey.

In Eb. 553- 554, the remedy was for driving out 'crushing' of dental ulcers and to strengthen the flesh without knowing if it included the periodontal tissue, or perhaps, ulcer meant 'caries'. It was probably a warty labial fistula (*sHmw*) of dental origin. The treatment applied locally was composed of unknown plants, carob and honey. In H. 8 (1, 7) tooth was starting to fall apart and would finish destroyed by an abscess with inflammation (*bnwt*) and swelling, it was treated with 'chewing' (*khepau*). Another inflammation (Bln 76), which distorted the cheek by pulling back the labial commissure, was treated with fumigations. In Eb. 749 a violent, spontaneous and pulsatile pain was caused by blood that ate (*wnm*) inside a tooth (*m ibH*), a pathogenic principle like in Eb 722/724. It was a perirradicular syndrome or dental abscess with painful throbbing (*srwx*) which swelled the flesh. The controversial description of an eating disease that presented signs of blood was interpreted by Ebell as scurvy but as pyorrhea by Lefèbvre. It was treated with colocynth, sycamore, gum and other plants to be chewed for 4 days. In Eb. 742 a tooth was eating the flesh at the mouth, suggesting a sharp projection causing ulceration of tongue or cheek. The remedy comprised cumin, incense (*sntr*) and carob (*Daret*), applied as powder [82].

> *"Another remedy for treating an itching tooth until the opening of the flesh: cumin, 1 part; resin of incense, 1 part; DArt-fruit (= carob), crushed and applied to the tooth"(Eb. 742).*

A 12th Dynasty mandible with two circular openings in the region of the apex of the first molar was described by Breasted [83] as a perforation deliberately drilled to evacuate pus from abscesses but Leek and Hooton[84] thought that these were merely natural openings made by the pus working its way out, as we already explained. It could be a pathological case of dental *wxdw*. However E. Hooton [85] described two drainage holes in a mandible of the fourth Dynasty for treatment of apical abscesses, showing that Egyptian dentists intervened surgically. Extreme pain might have been medicated with opium. In Eb. 747 the treatment drove out growth of *wkdw* and in Eb. 745 the tooth, perhaps with

attrition or gingival pathology, was treated by 'chewing' (*khepau*). (Eb 745).

The instruction of Ankhsheshonq [86], dated tentatively to the Ptolemaic period, although the content may be earlier in origin with a list of maxims on many topics, contains this maxim: '*There is no tooth rots if yet stays in place*'. From the pharaonic period no recorded documents that hasten this process and no tools suited have been found as forceps or levers [87] and nothing is known about tooth extraction, though some remains show signs of forced tooth removal and perhaps sometimes the mobility of the piece would allow manual removal. But according to the skulls examined by Leek, some teeth must have been removed from strong and well developed arches and so some method of removal of teeth was probably known or practised [88], because in the *Acts of Martyrs* the tongs were used as torture instruments to pull out molars [89]. Dawson [90] cites the following prescription from Roman times, found in the 9th century Meshaik Coptic Medical Papyrus: '*To extract a tooth with instruments. Apply good quality hellebore and gall on the cheek near the molar to be extracted and you will be surprised*".

Replacement of teeth has been found, although it is no clear whether they were *post-mortem cosmetics*. Pharaonic physicians made reconstruction works and replacement of teeth with a dental bridge, one or more lost teeth reattached by means of a gold or silver wire to the surrounding teeth, at least in three instances. One, dated in the Fourth Dynasty, was found in a mastaba in the necropolis of Giza. This item is now in the Pelizaeus Museum in Hildesheim [91]. Belonging all of these to the same individual, the tooth was keeping in place with a contraption made of a gold wire woven around the gingival margins of two adjoining teeth, a primitive work similar to mechanic's job performed under difficult condition in an oral cavity. Leek [92] asks himself if it was performed during the patient's life or after his death - to tidy them up before their burial - but the gold wire and teeth were covered with tartar, indicating that they had been in the mouth some time before death. The post-mortem tooth insertion has been interpreted as a sacred offering and ritual reenactment to change milk teeth, a passage towards young adulthood to be reborn at this stage. Junker in 1914 [93] maintained that these 'bridges' or prostheses responded to touch-ups by embalmers, although also for Professor Euler, director of the Breslau Dental Institute, the tartar present on the wire suggests that it was carried out on a living person [94]. A third molar in this case, showed extreme wear in the crown and its roots were almost completely absorbed. Another Greco- Roman example shows a maxillary bridge in two upper right incisors fastened together with silver wire to hold an artificially prepared central incisor in position [95].

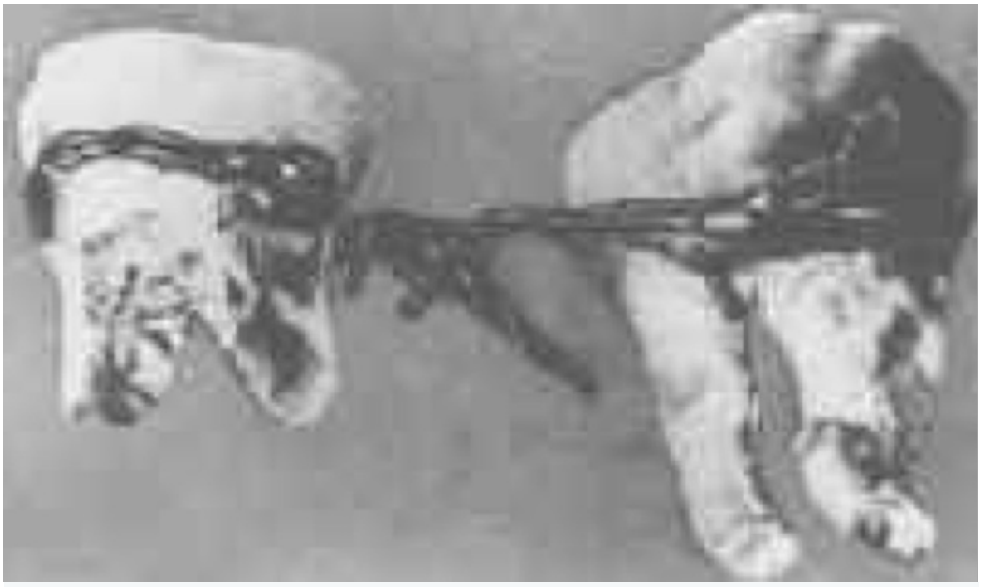


Fig. 17. Mandibular second molar connected by gold wire to a third molar, discovered in a Giza burial dating 2500 BC, Giza bridge, Roemer and Pulizaeus Museum Hildesheim (from R. Forshaw, “Were the dentists in ancient Egypt.., fig 3, 74)

P. Edwin Smith (7) illustrates the possible development of tetanus due to an abscess in a skull fractured base of a patient with meningeal irritation. The cord of the mandible, probably the temporalis muscle which closed the mouth and jaws, were contracted. The sick, pale and exhausted, suffered neck stiffness, toothache, eyebrows and face distorted with the *risus sardonicus* (the grimly jocular smile of tetanus) for the inability to open the mouth (trismus*tiAw*), without pain. A chisel of wood was used to open the mouth due to the jaw spam. But the teeth and back were left without observation.

Conclusions

For current odontologists in Ancient Egypt no traumatic surgery or surgical dentistry with actual incision existed, although the few examples of wired or bridged teeth known come from the Old Kingdom when dentistry was acknowledged as a branch of medicine. It was still hotly debated if they have been reconstructed during mummification or manufactured as a charm. Besides dental remedies in the extant medical papyri are non-surgical and no undisputed dental artifacts or depiction of them have been found from Pharaonic times [96].

Despite the complete references studied above for the treatment of toothache, infections and loose teeth, it seems that the knowledge of dentistry was very limited because powerful rulers did not show evidences of any form of dental treatment for their extensive dental diseases. Thus, Amenhotep III and Ramesses II suffered extensive tooth wear, dental abscesses and advanced periodontal disease that must have caused considerable pain and loss of life quality. So this review has been able to highlight the various pathological and non- pathological tooth conditions, similar to the present problems, despite the changing conditions and solutions. Oral health was poor in ancient Egypt and, with little evidence of dental care, infection and oral pain must have been widespread. The operative dental treatment and the management of dental conditions, undoubtedly, were restricted to the pharmaceutical preparation listed in the medical papyri. *These*

remedies were directed towards the symptoms of the problem, rather than the cause, and at best will only have provided some short term relief [97].

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12. ^*Coffin Texts 173; III 57 e-h: "I opened my mouth, I eat life, I live on air, I live again forever".*
13. ^*The Osiris myth, more detailed and more cohesive than any other, reached its basic form before 2400 BC, originated in religious ideas, but the struggle between Horus and Seth may have been partially inspired by a regional conflict in Egypt's early history or prehistory. Parts of the myth appear in a wide variety of Egyptian texts, from funerary texts and magical spells to short stories. Greek and Roman writings, particularly De Iside and Osiride by Plutarch, provide more information that not always reflects accurately Egyptian beliefs, than different Egyptian sources which vary widely in*

their version of events.

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