Equine Dentistry and Maxillofacial Surgery

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Edited by

Jack Easley, Padraic Dixon and Nicole du Toit

Cambridge Scholars Publishing

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PREFACE AND ACKNOWLEDGEMENTS

First and foremost, disorders of the equine head and mouth, while of prime importance, have long been slighted or ignored. Historically, some barbaric practices in equine dentistry have often *added* to disease processes and the suffering of horses. Over the last century, human and veterinary medical practitioners have made dramatic improvements in both understanding the causes of dental disease and its accurate diagnosis and treatment. More specifically, dedication of those professionals interested in the field of equine dentistry has brought motivation and purpose to the creation of this text. Its contents represent a single comprehensive source for the latest basic and advanced clinical research with descriptions of new and innovative techniques to treat horses with dental and maxillofacial diseases.

This new text has been created to cover modern diagnostics, microbiology, cancer diagnosis and treatment, endodontic and periodontic diagnoses and treatment, dental surgical techniques, and maxillofacial and sinus surgery. It is written for and dedicated to veterinarians who are interested in practicing quality dentistry at all levels from students just entering the field to residents and experienced practitioners desiring to provide the best dental care.

We have assimilated worldwide, knowledgeable contributors from private equine practice and academia that wish to share their expertise with colleagues and students for "the good of the horse". We are indeed grateful for the authors' contributions. Thank you to those who have supported advancement in this field including the family and friends of the editors and authors; faculty, staff, co-workers and students; and researchers who have been self-funded and funded through grants and industry.

The editors use the philosophy "building on the past, perfecting the present, and improving the future". May the process continue--this is unfinished work.

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SECTION 1:

INTRODUCTION

CHAPTER 1

EQUINE DENTAL EVOLUTION

PENNILYN HIGGINS AND JACK EASLEY

The History of our Understanding of Equine Evolution

Today, the evolutionary history of the horse is showcased as among the best examples in support of the modern theory of evolution. Using dental characteristics and some aspects of the structure of the limb, paleontologists have been able to trace horse ancestry to small, fox-sized browsing mammals that arose not long after the extinction of the dinosaurs. This understanding has developed over the last two centuries, beginning before the modern principles of evolution were even understood.

Early Understandings

The study of horses and their distant ancestors (members of the Suborder *Hippomorpha* - horse-shaped animals) has taken place over the last two centuries. Among the first members of this suborder to be described was *Palaeotherium*, named and described in 1804 by Baron Georges Cuvier (1) from specimens collected near Paris, France. Cuvier is regarded as the "Father of Paleontology" because of his contributions to establishing the science of paleontology in the early 19th century.

In 1841, Sir Richard Owen (2) described and named the genus *Hyracotherium* based partly upon a skull and lower jaw that contained teeth that were found in the London Clay (in England). At the time, Owen thought it may be a pachyderm species (such as an elephant) and noted its similarity to the hyrax. Later in 1876, Othneil Charles Marsh (3) described a complete skeleton from the Western part of North America and named it *Eohippus*. In 1932, Sir Clive Forster-Cooper (4) noted that *Eohippus* and *Hyracotherium* were the same animal. Since *Hyracotherium* was named before *Eohippus*, the name *Eohippus* is regarded as a junior synonym and is no longer used. However, many species formerly included within *Hyracotherium* have been divided into new genera including *Sifrhippus* and a resurrected *Eohippus* (5).

In 1859, Charles Darwin published *The Origin of the Species* (6), initiating an intellectual confrontation between evolutionists like Darwin and Thomas Huxley against those who believed in special creation of the species. Huxley later promoted the idea that bones and teeth found in successive rock layers in the earth, provided a lineage illustrating Darwin's principles. Around this same time, the Russian paleontologist Vladimir Kowalevsky (7) recognized that *Hyracotherium* belonged in the Family Equidae. Today, *Hyracotherium* is generally regarded as the earliest member of the taxonomic family that includes modern horses, i.e. the Family Equidae.

In the mid-19th century Marsh, a professor from Yale University, paid bone collectors to send him fossils from the North American West. Using these fossils, he was able to demonstrate that the center of early horse evolution had been in North America, not Europe. He went on to publish his theories on the changes within the Equidae over geological timespans, including their loss of toes, increase in height, and the increasing complexity of their grinding teeth (8, 9).

Modern Understanding

The evolution of the Equidae is now used as the classic example of macroevolution in textbooks. Factors such as environmental change, competition for food, and predation are provided as driving forces resulting in a shift from a small, fox-like forest-dwelling animal to the large and powerful plains animals we see today.

While this series of evolutionary changes are often presented in a linear fashion, new discoveries and continued research show that horse evolution took many side branches that later became extinct, resulting in a family tree that is more bush-shaped than ladder-shaped. However, today only one branch of that bush remains in the Genus *Equus*.

Origins of the Equidae

Modern horses find their origins in groups of mammals that bear little resemblance to today's horses, zebras, and donkeys. The ancestors of horses were as noted, small, fox-sized browsers which themselves were derived most likely from five-toed small ancestors that moved between rocks and bushes for food. Today in contrast, horses and their relatives such as zebras, are fleet-footed inhabitants of open plains.

Origin of the Age of Mammals

The extinction of the dinosaurs at the end of the Mesozoic hastened the beginning of the "Age of Mammals" approximately 66 million years ago. This boundary occurs between the latest Mesozoic Period, i.e., the Cretaceous (abbreviated K), and the earliest Cenozoic Period, i.e., the Paleogene (abbreviated Pg), and is hence referred to as the K-Pg boundary. The K-Pg boundary marked by the global iridium spike caused by the asteroid impact on Mexico's Yucatan peninsula, the same impact event that caused the major climatic changes that killed the dinosaurs.

Despite the Mesozoic being called the "Age of Reptiles," mammals had existed alongside (or under-foot) of the dinosaurs for several million years. The late Cretaceous mammals, i.e. those that coexisted with dinosaurs, were typically small animals with teeth specialized for insectivory (an insect diet). Dinosaurs occupied most of the ecological niches at that time, especially those for medium and large-sized carnivores and herbivores. With the extinction of the dinosaurs, mammals rapidly diversified to occupy the newly opened ecological niches. Within five million years of the extinction of dinosaurs, mammals had evolved forms to occupy strict herbivore and carnivore diets. Some mammal forms appeared that were adapted to living in trees. Some familiar groups including rodents (Rodentia), now appeared.

Origin of the Perissodactyla

For the first ten million years or so of the Cenozoic, during the Paleocene Epoch, mammals diversified, and some modern mammalian orders appeared, including as noted rodents. But most mammals remained relatively small and belonged to earlier more archaic (primitive) groups of mammals (such as the Condylarthra and the Creodonta) for whom the relationships with modern mammalian orders remains unclear.

The Paleocene ended with a period of abrupt global warming which increased land temperatures as much as eight degrees Celsius globally over the course of 10,000 years. The cause of this warming remains the focus of intense research and is regarded as one of the best 'fossil' models for modern global climate change. Global temperatures dropped over the next 200,000 years to their previous levels.

This episode of global warming is termed the Paleocene-Eocene Thermal Maximum (PETM) and is used to mark the boundary between the Paleocene and Eocene epochs approximately 55 million years ago. This global event is significant in the evolution of mammals because it was during this time that the modern orders Primates, Artiodactyla (even-toed hoofed mammals), and Perissodactyla (odd-toed hoofed mammals) first appeared.

All members of the Order Perissodactyla share many skull and limb characteristics, the easiest to observe is that they have hooves and an odd number of weight-bearing toes. This is termed "mesaxonic" meaning that the middle toe (digit III) is the primary weight-bearing digit. In modern horses, the hoof is the only remaining visible digit. In rhinos and tapirs, there are three hoofed toes, the middle toe being the dominant one.

The mesaxonic feature appeared in the earliest Eocene in related species that are often grouped into the genus *Hyracotherium*, a small fox-sized mammal that probably browsed on low vegetation. From there, the members of the Family Equidae evolved into larger, more cursorial (i.e. adapted for running), and grazing-specialized species and eventually resulted in the familiar horse, a fleet-footed runner of open plains.

Diversification of the Equidae

For much of the evolutionary history of horses, they were small, multiple-toed, browsers, likely confined to more forested and brushy habitats. Environmental pressures, many of which arose during the Miocene Epoch of the Cenozoic, drove horses from covered woodlands into open plains. At the same time, horses experienced a dietary shift from primarily browsing to grazing (Fig. 1.1). The shift in habitat and diet had profound effects on the body form of horses, including a further decrease in size of the side toes, lengthening of the nose, and a trend toward taller teeth.

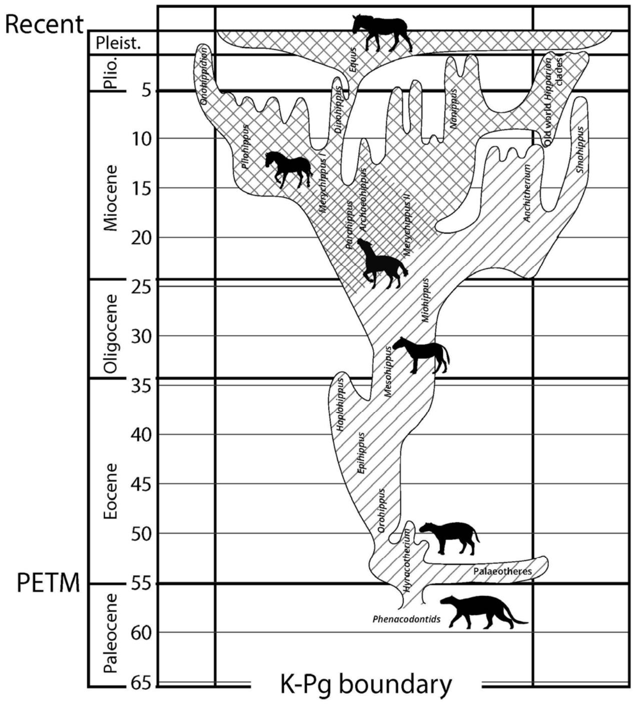

Figure 1.1. Phylogeny of horses. Silhouettes are the genera featured in Figures 1.2, 1.4 and 1.5. Adapted from (18).

The common hypothesis is that global cooling, along with the advent of open grasslands and more abrasive diets, resulted in an adaptive advantage to horses with higher-crowned and flatter teeth. *Parahippus* was among the first horses to see increases of tooth height relative to its anterior-posterior (mesial-distal) length, which became extreme in the subfamily Equinae (including *Equus* [10]).

Modern Equids

All living members of the Family Equidae belong to a single genus, *Equus*. Three distinct clades (organisms united by sharing a common ancestor) comprise the Genus *Equus*.

First, the "caballine horses" include all domesticated horses (*E. ferus caballus*) and the endangered Przewalski's horse (*E. ferus przewalski*i), the only population of truly wild horses on the planet. Zebras form the second clade, which includes three species (*E. zebra*, *E. quagga*, *E. grevyi*) plus a number of subspecies and morphotypes. The third clade are the wild asses, which includes the African wild ass (*E.* africanus) and its domestic form the donkey (*E. africanus asinus*), the Asian wild asses (*E. kiang* and *E.* hemionus), the latter includes several recognized subspecies. The zebras and wild asses are informally referred to as the "non-caballine horses."

The extant diversity also includes hybrids, as the various species above are capable of interbreeding. These hybrids are sterile with rare exceptions. The most common hybrid is the mule, a cross between a male donkey and a female horse. The reciprocal hybrid (cross between a male horse and female donkey) is also possible and is called a hinny.

Orlando et al (11) studied 560–780-thousand-year-old horse remains to investigate the timing of the divergences among these three clades. Their results suggest that the last common ancestor of modern horses, donkeys, and zebras existed 4.0-4.5 million years ago (11). Further, their study suggests that Przewalski's horse diverged from the lineage that led to domesticated horses 38–72 thousand years ago, with no apparent cross breeding since this divergence.

Domestication of Horses

It is thought that the Enelothic (approximately Copper Age, 4th millennium BC) Botai culture of central Asia was the first to domesticate horses from Przewalski's horses. Ancient genomes of Botai horses and Przewalski's horses suggest that Przewalski's horses may be a feral remnant of domesticated Botai horses (12). However, Boyd et al. (13) suggest that the genetic results do not support this conclusion and it remains unclear whether Przewalski's horse remains the only surviving truly wild caballine horses living today.

Evolutionary trends from the origins of the Perissodactyla to Equus

Fossils provide a record of the evolutionary changes that occurred as small, multi-toed condylarths (an extinct order of early ungulates) evolved into modern horses. Much of the change occurred during the Miocene as horses diversified and dispersed globally as grasslands and plains opened up.

Three major trends occurred leading to the features we recognize today as unique to horses.

1) Toes were lost and legs lengthened as horses evolved for swift locomotion in open environments.
2) Teeth became tall and flat, an adaptation for extended mastication of abrasive and low-energy foodstuffs like grass.
3) The skull lengthened and jaws deepened to accommodate taller, broader teeth and also to lift the eyes away from the ground to allow the horse to observe its surroundings while grazing.

Limb Structure

The evolutionary history of the Family Equidae is marked by limb elongation and digit reduction, representing a shift from smaller mammals browsing in a more closed undergrowth beneath a forest canopy (an understory) environment to larger running mammals preferring open grasslands. Early members of the Equidae, such as *Hyracotherium*, possessed four digits on the front limb and three on the rear limb (Fig. 1.2). These limbs were mesaxonic, with digit III bearing most of the weight through the limb. All members of the Equidae possess this characteristic to the extreme of the modern horse which bears its weight on only one toe, i.e. that of digit III. The three-toed foot (tridactyl) with an enlarged middle toe and two smaller hoofed toes on each side characterize much of equid history between the most primitive equids and modern members of the Tribe Equini. Tridactyl equids radiated globally from their origins in North America filling mostly browsing niches throughout the old world.

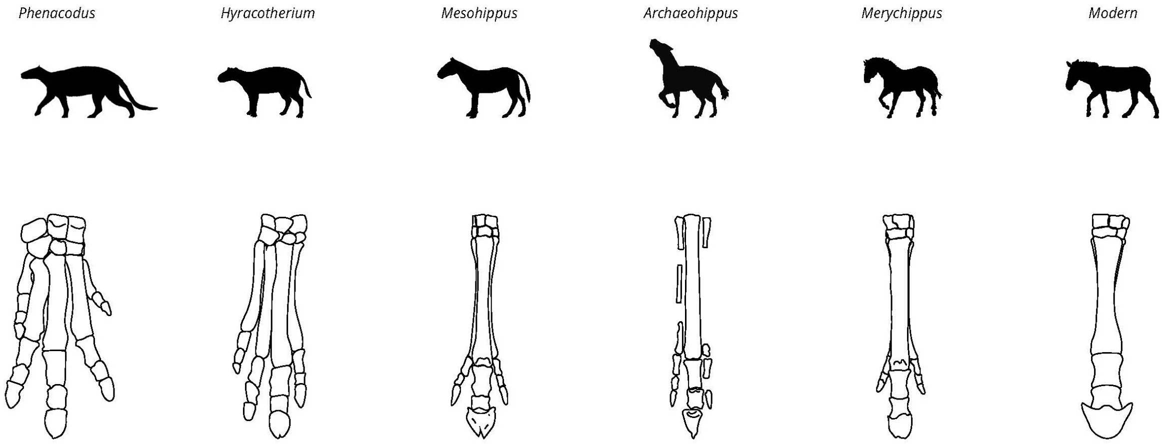

Figure 1.2. Evolutionary trends in the forelimbs of horses.

It was during the Miocene Epoch (approximately 23 - 5.3 Ma) that horse limbs made the greatest shift from the shorter limbs of a browsing mammal to the long slender limbs we associate with horses today. Limbs were simplified and joint motions limited to flexion and extension as an adaption to cursoriality (running) in more open environments. A reduction of toe numbers and limitation of motion stabilized the limbs.

At around 18 Ma, *Merychippus* appears in the fossil record, representing the first horse species that is readily recognizable as a type of horse, including greatly reduced lateral toes, elongated limbs adapted for running, and taller teeth approaching hypsodont proportions (see discussion on tooth structure) with complex enamel patterns, more similar to those of modern horses than to their ancestors.

By 9 Ma, all equid taxa bore the limb structure of cursorial (running) mammals, the browsing short-limbed forms having disappeared. *Equus* originated in North America at about 4.5 Ma (Pliocene Epoch) and subsequently dispersed to the Old World, likely across the Bering Land Bridge between today's Alaska and Siberia.

Tooth structure and function

The teeth of all placental mammals are derived from the primitive tribosphenic molar (Fig. 1.3). Structures have similar names where "cone" is used to indicate a cusp or point, "conule" denotes a smaller cusp, "crista" is a simple ridge, and "loph" is a complex ridge formed between cusps as enamel is worn away and the dentine interior of the tooth is exposed. In general, the structures in maxillary and mandibular molars are given similar names, but the suffix -id is added to the name of structures in mandibular molars.

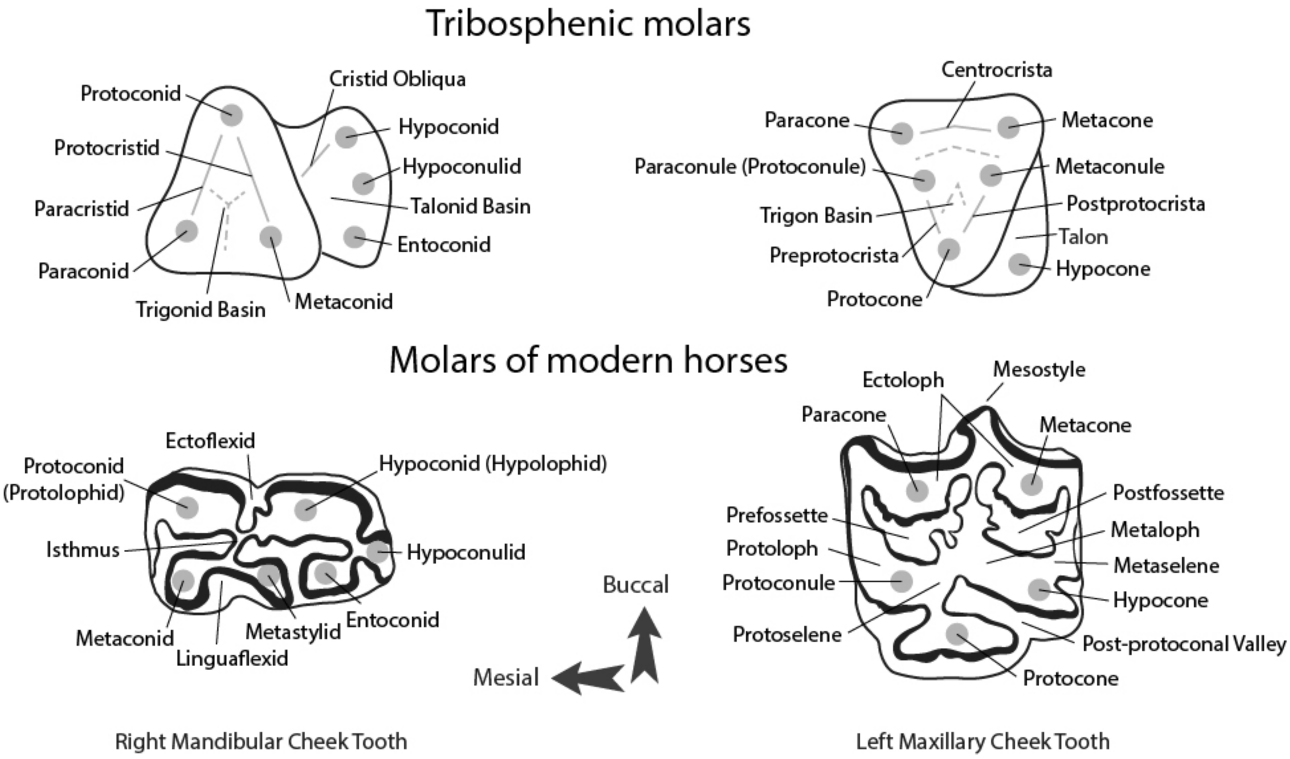

Figure 1.3. Terminology for describing structures of the occlusal surface of molars for generalized mammal teeth (tribosphenic molars) and for modern horses. Gray circles denote the location of the primary cusps of the tribosphenic molar.

In general terms, the tribosphenic molars are composed of a triangle of three cusps. In the maxillary molars, the apex of the triangle (the protocone) points toward the tongue, and the flat base (with the paracone toward the front of the mouth and metacone toward the back of the mouth) lies along the cheeks. The apex of the triangle of the mandibular molars (protoconid) rests against the inside of the cheek and the paraconid and metaconid (mesial and distal, respectively), form the base of the triangle against the tongue. This basic triangle is called the trigon in the maxillary molar and trigonid in the mandibular molar.

Distal to the trigon (or trigonid), on the same side of the tooth as the protocone (protoconid) is the hypocone (hypoconid) which outlines a basin or shelf called the talon (talonid). The protocone of the maxillary tooth fits into the talonid of the mandibular tooth creating a shearing surface between the trigon and trigonid unique to the tribosphenic condition (molars of an insectivorous animal).

Figure 1.4 illustrates the evolutionary sequence for equine teeth from the primitive tribosphenic condition to the teeth of modern horses. The Family Equidae likely evolved from a more primitive group of extinct ungulates called the condylarths. In particular, members of the condylarth Family Phenacodontidae are thought to be likely ancestors of the early equid *Hyracotherium*. Both the phenacodontid *Tetraclaenodon* and *Hyracotherium* possess an easily recognized tribosphenic form. However, *Hyracotherium* shows early development of the ridges joining cusps that later become the important grinding lophs (i.e., protoloph and metaloph) of modern horses.

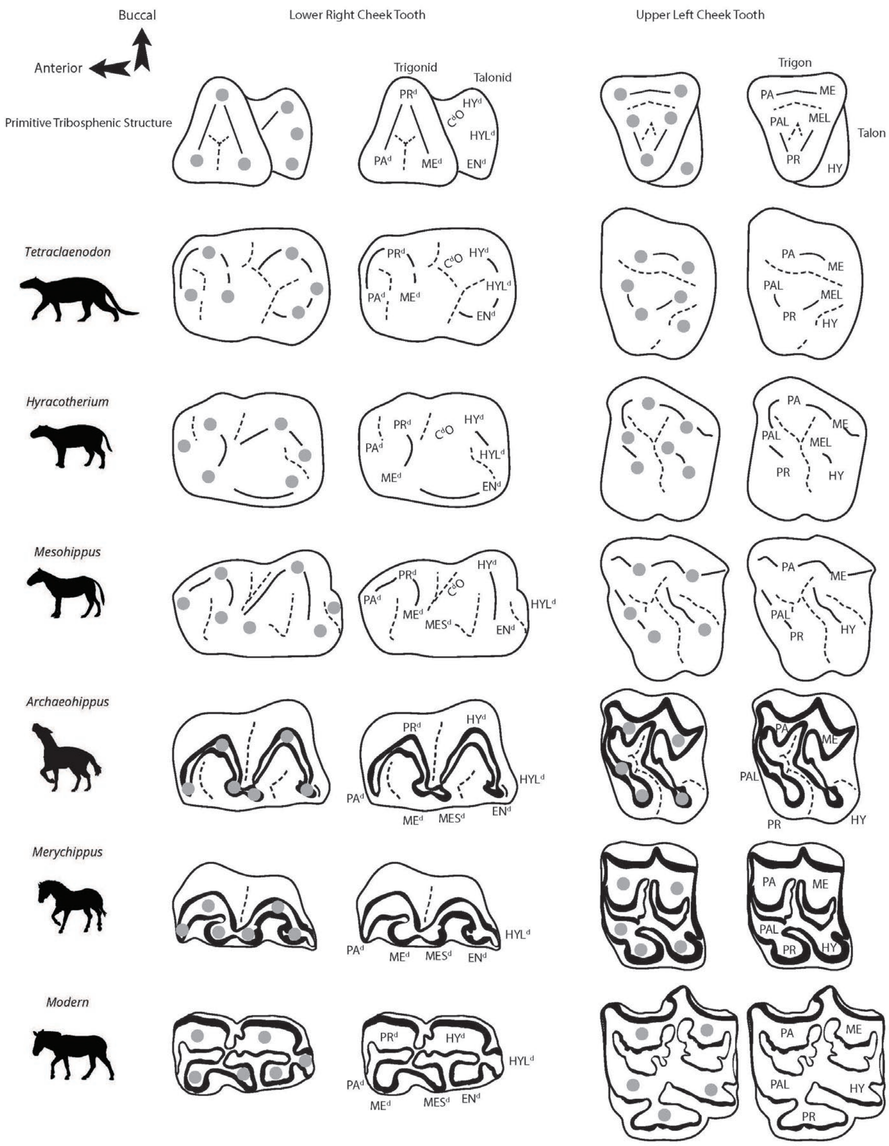

Figure 1.4. Evolutionary trends in the teeth of horses including the insectivorous (condylarth) *Tetraclaenodon*. Gray circles denote the location of the primary cusps of the tribosphenic molar. Abbreviations: Upper molars: HY = Hypocone, ME = Metacone, MEL = Metaconule, PA = Paracone, PAL Paraconule (Protoconule), PR = Protocone. Lower molars: CdO = Cristid Obliqua, ENd = Entoconid, HYd = Hypoconid, HYLd = Hypoconulid, MEd = Metaconid, MESd = Metastylid, PAd = Paraconid, PRd = Protoconid

Over time, these lophs become more elaborate, and the wearing down of enamel to expose occlusal dentine and form a complex grinding surface becomes more prevalent. By about 20 million years ago with horses like *Archaeohippus*, the original tribosphenic pattern becomes difficult to discern through the wear patterns. In the modern horse, pointed cusps are no longer evident. Instead, dentine is exposed where the cusps are worn away. Where basins in the tribosphenic tooth were present, deep, cementum-filled cup-like, enamel structures called infundibula are now present.

The primitive tribosphenic (insectivorous teeth) condition is brachyodont, meaning that the dental crown and the roots are short. This condition is defined by using the *hypsodonty index*, calculated by taking the ratio of the height of the crown of a tooth and comparing it to the anterior-posterior (rostro-caudal; mesio-distal) dimensions of the tooth. In brachyodont teeth, the hypsodonty index is less than 0.8, which means that the teeth are longer than they are tall (14, 15). Through much of the evolutionary history of horses, their teeth remained brachyodont. This changed during the Miocene Epoch (23 - 5.3 Ma) when horses began to evolve the modern, hypsodont condition. Hypsodonty is defined by a hypsodonty index of greater than 1.2. In modern horses, this index is often as high as 8.0. The cause of increasing hypsodonty in horses has, as noted, been attributed to dietary shifts to more abrasive and less nutrient rich (high cellulose) diets, associated with the opening of large grasslands and horses' change to grazing habitats.

In addition to increasing hypsodonty, the overall profile of teeth changed over the course of equid evolution. The profile shape of teeth can be described using *mesowear scores* (16). Mesowear is typically divided into two parts: tooth relief and cusp shape. The difference between low points and high points on the occlusal surface of a tooth, compared to the tooth length, constitutes relief. Cusps may be sharp, rounded, or blunt. Early horses, like *Hyracotherium*, had teeth with relatively high relief and rounded cusps, whereas the teeth of modern horse are of low relief with more blunted cusps (10). Combining mesowear interpretations with hypsodonty indices provides further insight into the dietary preferences of herbivorous mammals (16).

The cheek teeth, including three of the four premolars, became molarized in more recent equids, (including modern horses), as a further adaptation to a diet that require extended mastication. The exception to this is the first premolar, the so-called "wolf tooth", which has become reduced to a vestigial peg-like tooth, if present at all. Equine cheek teeth have a prolonged eruption over many years, to maintain an ideal crown height and shape as the teeth wear down. The exposed, functional part of the tooth is called the clinical or erupted crown, whereas that part of the tooth remaining unerupted in the jaw is termed the reserve crown. Cementum, typically present on the subgingival part of the tooth for periodontal ligament attachment to hold it in place, moves occlusally with dental eruption and is present on the periphery and within the infundibula of the clinical crown in equine teeth.

Cranial Anatomy

The morphology of skulls within the Family Equidae also underwent substantial changes across evolutionary history (Fig. 1.5). In general, the shift involved lengthening of the skull, in particular the preorbital area, resulting in an expansive diastema between the incisors and cheek teeth, and variable development of one or more fossae. Deepening of the jaws occurred as tooth structure shifted from brachyodont to hypsodont during the dietary shift from browsing to grazing.

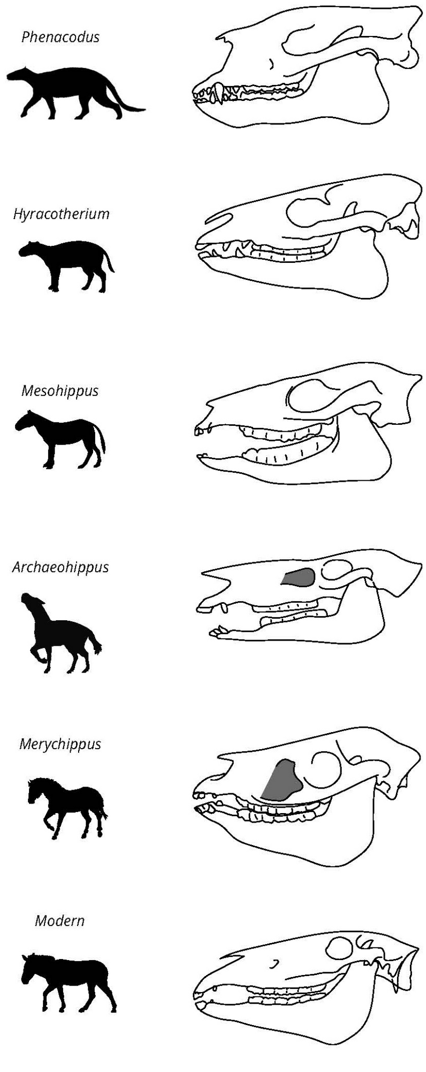

Figure 1.5. Trends in skull morphology in fossil and modern horses.

In the earliest equids such as *Hyracotherium*, the orbit was located about mid-way between the tip of the nose and the back of the skull. There was a small post-canine diastema and shallow jaws (dentary) that could accommodate their short-crowned teeth.

During the Miocene, the preorbital cheek region elongated, extending the physiological diastema ("bars of the mouth") between the incisors and cheek teeth. The canine teeth continues to be present within the diastema and ranged in size from quite prominent, especially in males, to vestigial or absent in females. The preorbital lengthening as noted, is presumably to raise the eyes further from the ground as an adaptation to view predators while grazing. As a consequence of the diastema, the clinical crowns of the mesial cheek teeth (Triadan 06s) have a caudal angulation to act as a buttress for the rostrally directed pressures due to masticatory mechanical forces in mammals and the opposite angulation of the caudal cheek teeth (Triadan 10s &11s). In *Hyracotherium* the preorbital region, where the nasal, maxillary, and lacrimal bones come together, was smooth.

As the preorbital region elongated, various depressions termed preorbital fossae, arose in several lineages of horses, although it is absent in modern *Equus* and the extinct Pleistocene genus *Harringtonhippus* (Fig. 1.6). It is unclear what the purpose of these fossae were, but it is suggested that they served a purpose to anchor the lip and nose musculature and that horses with well-developed preorbital fossae may have had extreme muzzle mobility reflecting more of a browsing feeding strategy, that would not have precluded grazing (17).

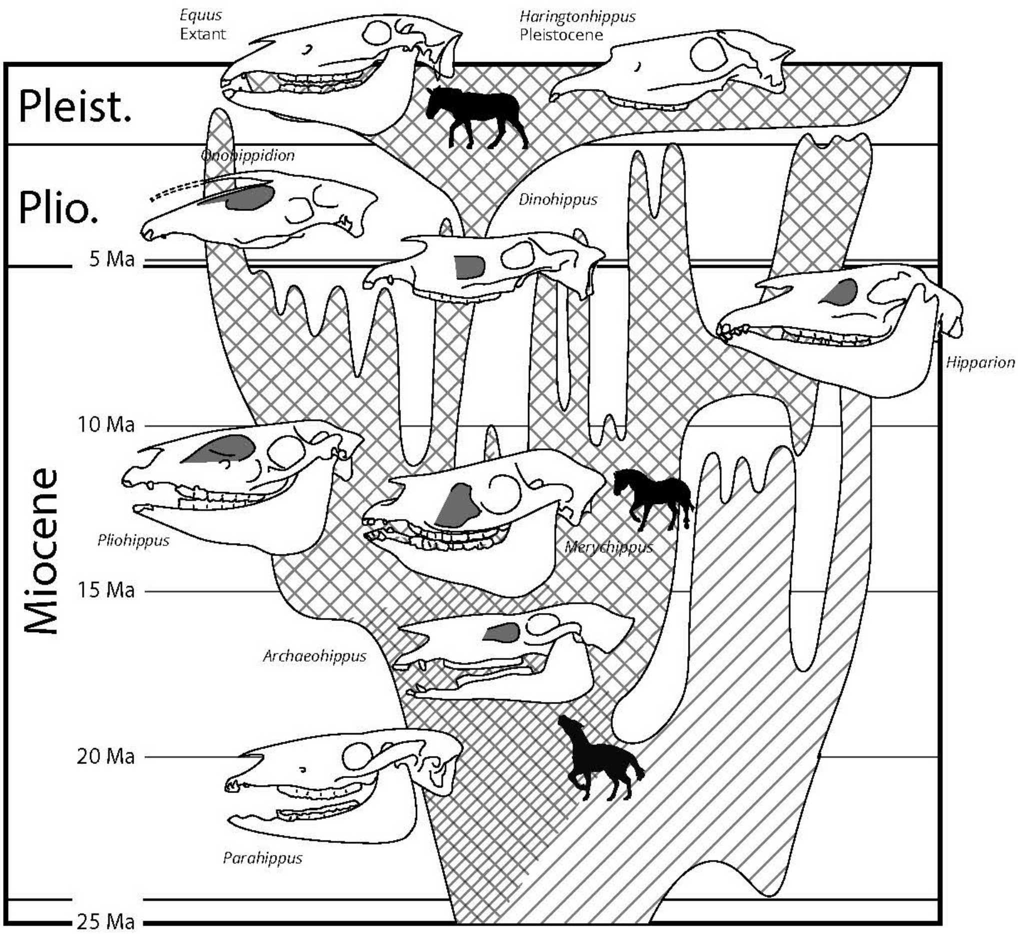

Figure 1.6 Skull morphology in Miocene through modern horses, illustrating the variability in the preorbital fossae. Skull sketches are superimposed on the phylogeny from Figure 1, illustrating how preorbital fossae occur in several lineages. Note the lack of such fossae in modern horses (*Equus*). Phylogeny adapted from (18).

References

1. Cuvier G. Sur les espèces d'animaux dont proviennent les os fossiles répandus dans la pierre à plâtre des environs de Paris. Ann Mus Nat Hist Paris. 1804; 3: 275-303
2. Owen R. XX.—Description of the fossil remains of a mammal (*Hyracotherium leporinum*) and a bird (*Lithornis vulturinus*) from the London Clay. Transactions of the Geological Society of London. 1841; 52: 203-208.
3. Marsh OC. Notice of new Tertiary mammals. Am J Sci. 1876; 12: 401-404.
4. Forester-Cooper C. The genus *Hyracotherium*. A revision and description of new specimens found in England. Philos Trans R Soc Lond B Biol Sci B. 1932; 221: 431–448.
5. Froehlich DJ. Quo vadis eohippus? The systematics and taxonomy of the early Eocene equids (Perissodactyla). Zool J Linn Soc. 2002; 134: 141–256.
6. Darwin C. On the origin of species by means of natural selection. London: J. Murray, 1859.
7. Kowalevsky V. Sur l'Anchitherium aurelianense Cuv. Et sure L'historie paleontologique des chevaux. Memoires de l'Academie Imperiale Science, St Peterssbourg 7th Serie. 1873: 20: 1-73.
8. Marsh OC. ART. LXIII.—Polydactyle Horses, recent and extinct: Am J Sci, 3rd series. 1879; 17: 499-505.

9. Marsh OC. ART. XLIII.—Recent Polydactyle Horses: Am J Sci, 3rd series. 1892; 43:339–355.
10. Mihlbachler MC, Rivals F, Solounias N, Semprebon, GM. Dietary change and evolution of horses in North America. Science. 2011; 331: 1178-1181.
11. Orlando L, Ginolhac, A, Zhang G, Froese D, Albrechtsen, A, Stiller M, et al. Recalibrating *Equus* evolution using the genome sequence of an early Middle Pleistocene horse. Nature. 2013; 499: 74–78.
12. Gaunitz C, Fages A, Hanghøj K, Albrechtsen A, Khan N, Schubert M, et al. Ancient genomes revisit the ancestry of domestic and Przewalski's horses. Science. 2018; 360(6384): 111–114.
13. Boyd L, King S, Moehlman P, Amato G, Warmuth VM, Badamjav L. RE: Ancient geonomes revisit the ancestry of domestic and Przewalski's horses. Science [Internet]. 2018. Available from https://science.sciencemag.org/content/360/6384/111/tab-e-letters
14. Raia P, Carotenuto F, Eronen JT, Fortelius M. Longer in the tooth, shorter in the record? The evolutionary correlates of hypsodonty in Neogene ruminants. Proc Biol Sci. 2011; v. 278, 3474-3481.
15. Van Valen L. A functional index of hypsodonty. Evolution. 1960; v. 14, 531-532.
16. Fortelius M, Solounias N. Functional characterization of ungulate molars using the abrasion-attrition wear gradient: a new method for reconstruction paleodiets. Am Mus Novit. 2000; 3301: 1–36.
17. Bernardes C, Sicuro FL, Avilla LS, Pinheiro AEP. Rostral reconstruction of South American hippidiform equids: New anatomical and ecomorphological inferences. Acta Palaeontol Pol. 2013; 58: 669–678.
18. MacFadden BJ. Fossil horses—evidence for evolution. Science. 2005; 307: 1728–1730.

CHAPTER 2

MILESTONES IN EQUINE DENTISTRY

JACK EASLEY

Introduction

The history of human civilization spans many thousands of years, most of it unrecorded and is explained based on our present interpretation of archeological findings. The progress of equine dentistry parallels in many ways the history of human development including the domestication of the horse and other livestock and the scientific progress of human and veterinary medicine and dentistry. This chapter is written as a timeline of what this author believes are the major milestones in the development of modern equine dental practice to its current state. As we can see in present times from information flowing from social media via the internet, a good story or narrative is essential for having news disseminated. At times, the narrative is much more important than the truth or facts. This may explain some of the myths and superstition that accompany certain dental disorders and treatments in equine practice. It may also explain how some treatment methods, even though ineffective and cruel, were passed down through generations of equestrians and practiced for centuries. The information presented here is from my own reading of the relevant literature over a 45-year career in equine veterinary practice. I apologize to researchers, historians, paleontologists, and archeologists for not being able to obtain the original references for some material presented in this chapter. If that makes this chapter historical fictional, that is acceptable to me.

Prehistoric Times

People from Middle Eastern countries began to experiment in the field of veterinary medicine around 9000 BCE. Ancient sheepherders had a crude understanding of medical skills and Egyptian hieroglyphs dating from 4000 BCE record how herbs were used to treat and promote good health in domesticated animals. The first known veterinarian is Urlugaledinna, who lived in Mesopotamia during the Bronze Age, served under Ur-Ningirsu (2121-2118 BCE) and was considered an expert in his ability to heal animals. (Figure 2. 1)

Figure 2.1. Burial cylinder seal of Urlugaledinna– essentially his personal identification – shows a pair of tongs along with Ningirsu's staff of intertwined serpents. He was associated with animal healing more than treating humans though no details as to how his practice developed is available.

The earliest evidence of ancient human dentistry was found in a Neolithic graveyard in ancient Pakistan from skeletal remains of people of the Indus Valley Civilization. Researchers recently carbon dated at least nine skulls from this site, dated from around 7000 to 5500 BCE that showed evidence of precision holes drilled in teeth. Flint drill heads were found at this site and researchers believe that a small bow was used to drive the flint drill tips into patients' teeth. This dental drilling equipment probably evolved for drilling intricate ornamental beads. Although it is speculated that the drilling could have been decorative or to release "evil spirits" rather than for treating tooth decay, the hard-to-see locations of the drilled molar teeth seems to rule out drilling for decorative purposes. No signs of dental fillings were found. (1)

Hesy-Re, an Egyptian scribe often referred to as the first "dentist", died circa 2600 BCE and his tomb is inscribed with: "the greatest of those who deal with teeth, and of physicians." This is the earliest known reference to a person identified as a dental practitioner. About this same time, the Egyptian "Imhotep" describes the diagnosis and treatment of 200 medical diseases afflicting humans.

The oldest written documents on dentistry are from Egypt and are in the Edwin Smith Surgical Papyrus. It contains detailed directions for the treatment of wounds of the mouth region. The hard tissues of the mouth were, in general, considered untreatable. In closing his discussion on this topic, one ancient Egyptian surgeon advises: "One having a fracture of the mandible over which a wound has been inflicted and he has fever from it, it is an ailment not to be treated". Other archaeological evidence of dentistry in ancient times suggests that treatments included medical methods of combating dental affections, mechanical means of dental treatment such as retentive prosthesis and the art of applying artificial substitutes for lost dental structures. Examination of the remains of some ancient Egyptians and Greco-Romans reveals early attempts at dental prosthetics and surgery.

In the 18th century BCE, the Code of Hammurabi referenced dental extraction twice as it related to a punishment. This is one of the earliest sets of laws found and one of the best examples of this type of document from ancient Mesopotamia. The Codex is a collection of legal decisions made by Hammurabi during his reign as king of Babylon. These are inscribed on an eight-foot-tall stela of black diorite. By writing the laws on stone they were thought to be immutable. This concept lives on in most modern legal systems and is given rise to the term *written in stone*. The stela is currently on display at the Louvre Museum in Paris, France.

The domestication of horses, more than any other single factor, underwrote many of the major sociopolitical developments over the past several millennia. Archaeologists hypothesize that a strange dental wear pattern found on a horse from the site of Buhen, Egypt, dated to ca. 1675 BCE was produced by dental filing (floating) of the lower second premolar (Triadan 06) or by "bit wear," damage caused directly to a tooth by the use of a bit. Syrian texts from the Hittite Empire, dating to the 14th century BCE, describe the correct feeding of chariot horses and treatment of key ailments. In China, domestic horses first appeared during the end of the Shang Dynasty, ca. 1200 BCE. The archaeological and historical records indicate that the earliest horseback riding was accomplished without stirrups or saddles, and probably using only bitless or organic-mouthpiece bridles. (2)

The bronze snaffle bit, and the improved control it provided, was a key technological development that enabled the use of horseback riding for more stressful and difficult activities, such as long-distance transportation and warfare. (2) Recent archaea-zoological data from Mongolian equine skeletal remains spanning the past 3,200 years, indicate that nomadic equine dental practices are much older than once thought. Anthropogenic modifications to malerupted deciduous central incisors in young horses from the Late Bronze Age demonstrate their attempted removal, coinciding with the local innovation or adoption of horseback riding and the expansion of Mongolian pastoral society. Equine skeletons from this period show no evidence of first premolar ("wolf tooth") removal, which was first identified in specimens dating to ca. 750 BCE. The onset of first premolar extraction parallels the archaeological appearance of jointed bronze and iron bits, suggesting that this technological shift prompted innovations in dentistry that were believed to improve horse health and horse control. These discoveries provide the earliest directly dated evidence for veterinary dentistry and suggest that innovations in equine care by nomadic people ca. 1150 BCE enabled the use of horses for increasingly sophisticated riding and warfare. (2)

Ancient Times

One of the earliest equine veterinary texts is credited to a Chinese author from the "Spring and Autumn Period", ca. 770–476 BCE. The first definitive record of horse dentistry also comes from an early Chinese veterinary text dating to ca. 600 BCE, which describe the method of aging a horse through changes in its incisor dentition.

In Ancient Greece, Hippocrates and Aristotle wrote about human dentistry, including the eruption pattern of teeth, treating dental decay and gum disease, extracting teeth with forceps, and using wires to stabilize loose teeth and fractured jaws. Aristotle (B.C. 384) stated "The horse and the mule attain perfection after casting their teeth, and when they have cast them all, it is not easy to know their age. The ass sheds its first teeth at thirty months old. The second six months afterward. The third and fourth in the same way. These fourth teeth are called the marking teeth." (3)

Varro (116 BCE) is documented as saying: "Should they desire to form herds of horses and mares, such as are seen in the Peloponnese and the Appulia, they should first, ascertain the age of the individuals, which, it is said, must not be less than three nor more than ten years old. It is by the teeth that they find out the age of a horse, as well as that of all split-footed animals." He describes the shedding of deciduous incisors and describes the "cups" as hollows in the teeth and that begin to fill up by the sixth year.

1st Millennium

In the early 1st century AD various written records from China mention the treatment of equine disorders and detailed diagrams of equine anatomy and their acupuncture points have been discovered. It is said that Chinese horse anatomy/acupuncture books predate human acupuncture maps, because horses were considered so much more valuable than people!

Columella: (c 42-70 CE) thought that it was better to get rid of suppuration with the surgeon's knife, rather than with medication, and then to wash the wound with warm ox urine and bind it up with linen bandages soaked in liquid pitch and oil. Even at this early time, it was obviously appreciated that an infected wound would not heal without first removing infected tissue or exudate. He also wrote that "A horse may be broken for domestic uses when two years old: but when intended for war he must be over three years, so that he may not be exposed to it before he has accomplished his fourth year". He goes on the describe the shedding and eruption of incisors and was the first to describe the shedding of cheek teeth. (He states that the upper molars "fall" about the sixth year). He describes the "cups" as filling up from inside, as it was not understood that the teeth were simultaneously erupting and undergoing wear on the occlusal surface.

Galen (129-198 CE), a Greek physician, was the first to systematize medical practice and theory in the ancient world. His work was based on the ideas promoted by Hippocrates of Cos, 500 years earlier as well as Platonic, Aristotelian, and Stoic philosophy. He promoted the idea that health was the result of a balance between the soul, mind, and body. Disease, he suggested, was the result of an imbalance between the four humors (blood, phlegm, yellow bile and black bile). These humors were thought to be formed by the same elements that constituted the cosmos (fire, water, air, and earth). An imbalance of the humors or predominance of one or another quality (hot, cold, wet, and dry) was taught for centuries as the cause of disease. (4) This was the basis for the practice of bloodletting, purging, cupping, firing with a hot iron and many other barbaric practices that, unfortunately, were practiced until the 20th Century.

St Apollonia, the Patron Saint of Dentistry, was an early Christian martyr who suffered in Alexandria during a local uprising against the Christians about 250 CE. Dionysius, Bishop of Alexandria (247–265 CE), relates the sufferings of his people in a letter addressed to Fabius, Bishop of Antioch, of which long extracts have been preserved in Eusebius' *Historia Ecclesiae*. After describing how a Christian man and woman, Metras and Quinta, were seized and killed by the mob, and how the houses of several other Christians were pillaged, Dionysius continues: "At that time Apollonia, a virgin was held in high esteem. These men seized her also and by repeated blows broke all her teeth. They threatened to burn her alive if she refused to repeat after them impious words. Given, at her own request, a little freedom, she sprang quickly into the fire and was burned to death." (5) Saint Apollonia is popularly invoked against the toothache because of the torments she had to endure, which included having her teeth violently pulled out or shattered. She is often represented in art and iconography with pincers in which a tooth is held. (Figure 2. 2) Her iconographic image is used in the pin handcrafted by Dr. Peter Emily and presented every year to the recipient of the American Veterinary Dental Society/Hills Teaching Award, now referred to as the Jaguar Award.

Figure 2.2. Reliquary tooth of Saint. Apollonia, The Patron Saint of Dentistry, Cathedral of Porto, Portugal

In 330 CE, Apsyrtus of Byzantium is mentioned as the "father of veterinary medicine" and in 450 CE the Roman Vegetius wrote books on veterinary skills that were influential for hundreds of years. (4) Around 700 CE- A medical text in China mentions the use of "silver paste", (a type of amalgam) that was being used in dentistry.

Between 400 CE to 1000 CE, after the fall of the Roman Empire, Europe and much of the world fell into a time of war and destruction often referred to as the “Dark Ages or Early Middle Ages.” The Middle Ages was a brutal time for the toothache sufferer, with oral hygiene being almost nonexistent. Teeth were cleaned with pieces of linen or sponge, or by using small pieces of wood as toothpicks. Dentistry was not recognized as a profession. Barbers or barber-surgeons, marketplace charlatans, ‘tooth drawer’, and later the ‘Operator for the Teeth’ offered dental treatments that comprised of tinctures and styptics, with extraction as a last and painful resort.

In the Americas, the Toltics, who had preceded the Aztecs in the Valley of Mexico, subdued the Mayas about 1000 CE. Archeological evidence has shown that bow drills were used to place beautifully carved stone inlays in carefully prepared cavities in the upper and lower anterior teeth and even bicuspids. Skulls found from digs in Honduras dating to 600 CE have had pieces of shell inserted in place of the natural lower incisors. This is our earliest example of a presumably successful endosseous alloplastic implant operation on a living person. (6)

2nd Millennium

By 1200 CE, international trade increased again in Europe with expansion of the Silk Road. Culture grew, and art and education were no longer the sole realm of the Christian clergy. Artisans formed craft guilds, opened workshops, and sought commissions from the Church, government, nobility, and the increasingly wealthy merchant class, to create frescoes, panel paintings, and illuminated prayer books. One early remarkable example of these works is the illuminated book called the *Crusader Bible (Morgan Bible)* created in Northern France in 1240 CE and features action scenes, complete with battle wounds being inflicted, and detailed realism including specific types of weapons, spurs, armor, and other garments.

In China about 1297 CE, Wang Chen the magistrate of Ching-te printed a treatise on agriculture and farming practices using wood cuts (called Nung Shu). This is thought to be the first mass-produced book. It was exported to Europe and documented many Chinese inventions that have traditionally been attributed to Europeans. About 1267 CE a manuscript on early animal medicine was written in Japan. Horses had been introduced into Japan in the 3rd century but only nobility could own them. By 1500 CE they were being ridden by the Warrior Class; all others had to walk beside the horse hauling goods. (Personal communication David Ramey 2020).

Equine veterinary dentistry works from the 12th and 13th centuries reported treatments for inflamed gums, ointments to cure loose teeth and recommendations for the use of files and floats for trimming unequal teeth. The earliest structured written documentation about “horse medicine” occurred in the reign of Emperor Friedrich II (1212-1250 CE). He was an animal lover and his titles included King of Sicily, Duke of Swabia, Kind of Germany, and Holy Roman Emperor. He pursued his dynasty’s imperial policies against the papacy and the Italian city-states. He also joined in the Crusades, conquering several areas of the Holy Land and crowning himself king of Jerusalem (reigning 1229–1243 CE). In about 1350 CE in Italy, Laurence Rusius wrote *“Hippiatria”,* a book on horse medicine that became widely circulated 200 years later (once the movable type printing press was invented). This was a collection of previous work gathered together and translated from other versions of the *Hippiatrica*. (4) The original *Hippiatrica* is a compilation (mainly excerpts) of ancient Greek texts, dedicated to the care of horses from the 5th or 6th century, by an unknown Byzantine author.

Gaston Phoebus, the Count of Foix in France was one of the greatest huntsmen of his day and his treatise *Le Livre de Chasse* (1387 CE), became the standard text on medieval hunting techniques. He devoted two chapters to the care of wounds. “Wounds were not sutured and only bite wounds were treated. These were covered with raw wool drenched in olive oil, the dressings being changed every day for three days. The wound was then left open to the fresh air and the healing effect of the dog's tongue.” The former may have been a reasonably effective treatment as lanolin (present in raw wool) and oil have an emollient as well as a light anesthetic and antiseptic effect.

When the Black Plague struck Europe in 1348-1350 CE, much existing knowledge was in danger of being forever lost again, when one-third of Europe’s population died. This pandemic also resulted in the deaths of 75-200 million people in Eurasia and North Africa, before reaching Europe on ships laden with infected fleas and rats. However, after the plague subsided, wealth became more consolidated in the hands of fewer families, and there was increased patronage of the arts and education, which ultimately ushered in the Renaissance.

The German engraver Johannes Gutenberg in 1452 CE introduced the first movable type printing press. This allowed books to be printed cheaply which rapidly changed Europe by helping speed up the Renaissance and bring about the Christian Reformation. Leonardo da Vinci, Italian painter, draftsman, sculptor, architect, and engineer whose accomplishments epitomized the Renaissance humanist ideal, began to dissect corpses in the late 1480s. Books were written and distributed widely during the next 100 years. In Europe, Francisco de la Reyna’s *Book of Veterinary* was published in 1522 CE, *Art of Veterinary Medicine* written by Vegetius in 450 CE was translated and published in 1528 CE and Vesalius published findings on human anatomy in *De Fabrica Corpois Humani* in 1543 CE. Two Veterinary books, Thomas Blundeville’s *Book on Horses* and George Turbeville’s *Diseases of Dogs*, were published about this same time. Soon after this, Carlo Ruini of Italy published *Anatomy of the Horse*, prefacing the start of modern veterinary science. He describes deception in the horse-trading business. “Quackery was still widespread, and charlatans were a common part of rural life. Only the very wealthy could afford the skilled 'operator for the teeth'. For many the only option was the village blacksmith and tooth drawer offering painful extractions.”

Forceps and the 'pelican' were the most common extracting tools for humans and horses. The dental “pelican,” invented in the 14th century by Guy de Chauliac, was often made by the village blacksmith, needed little skill to use and often caused terrible damage and pain. The pelican was replaced by the dental key in the 17th century, and in turn was replaced by modern forceps in the 20th century. Modeled after a door key, the dental key was used by first inserting the instrument horizontally into the mouth, then its "claw" would be tightened over a tooth. The instrument was rotated to loosen the tooth. This often resulted in the tooth breaking, causing jaw fractures and soft tissue damage. (Figure 2. 3)

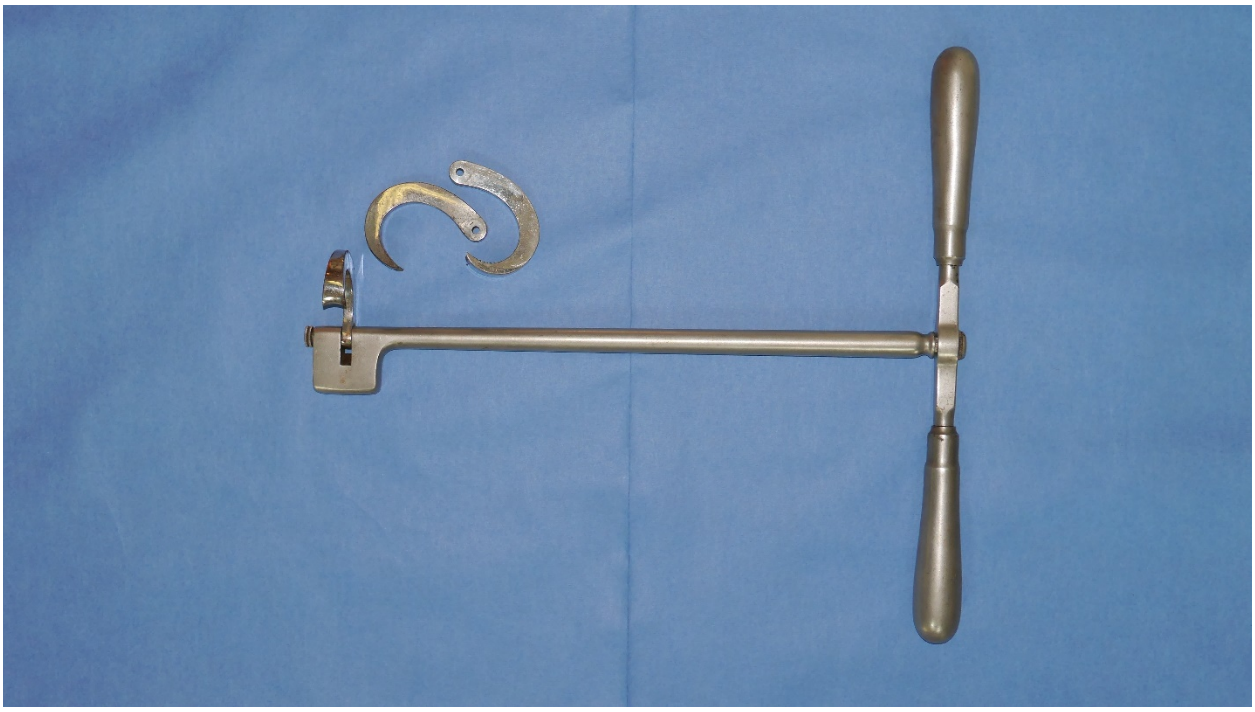

Figure 2.3. The Equine Dental Key with hooks of assorted sizes. This tool was designed to twist a tooth from its socket. This equine dental key was manufactured by J. Reynders-Co. in the late 1800s. (Easley personal collection)

Early attempts to regulate and organize the treatment of animals were mainly focused on horses, because of their great economic importance to society. By the end of the Middle Ages, farriers combined their trade of horseshoeing with general horse doctoring. When the Lord Mayor of London, learned about the poor care horses in London were receiving in 1356 CE, he persuaded all farriers within a seven-mile radius of the city to form a fellowship to improve and regulate how they treated horses. The fellowship led to the later creation, in 1674 CE, of the Worshipful Company of Farriers.

In the late 1630s, Thomas de Grey of England wrote *Hereditary Diseases and Common procedures Done on Horses.* He stated that “ Deception in the horse-trading business exploded as owners learned how to alter their horse’s dentition to mimic the tooth shapes and charactoristics of younger horses. This art of creative grinding became a crime. Several types of jewlers’ drills were used with great vigor throughout Europe.” (From the 1676 edition of *Markam’s Cheap and Good Husbandry*) In 1664, Jacques de Sollysel complained of people “bishoping” teeth which changed the shape in order to make a horse appear younger. This unethical technique was passed between horse traders, farmers, and commoners. (Figure 2. 4)

On the human medical front, Anton van Leeuwenhoek identified oral bacteria in 1683, using a microscope which had been invented by Zacharius Jennssen in 1590. He later went on to identify sperm and blood cells in 1690. In France, Ambrose Pare, known as the Father of Surgery, published his *Complete Works* (1575). This book includes practical information on dentistry such as tooth extraction and the treatment of tooth decay and jaw fractures. The first human dental textbook written in English was *The Operator for the Teeth* by Charles Allen, published in 1685.

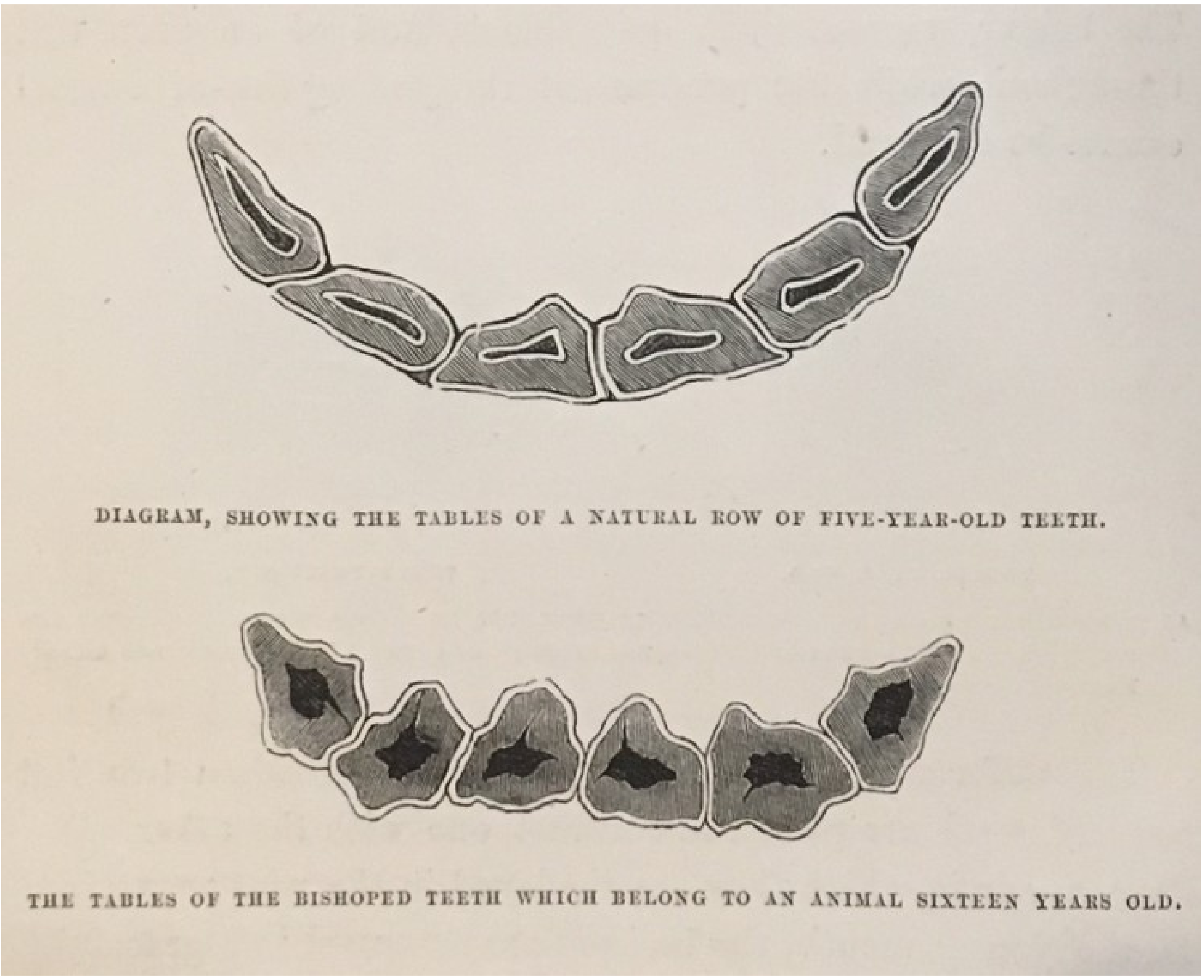

Figure 2.4. "Bishoped" incisors. This technique was used to make the mouth appear younger by cutting holes in the lower incisors to appear like "cups*". Mayhew's Illustrated Horse Management*: Revised and improved by James Irvine Lupton, MRCVS, 1876, page 127.

18th Century

In the 1720s, Pierre Fauchard, a French surgeon and inventor of a dentist drill, published *The Surgeon Dentist, A Treatise on Teeth* (*Le Chirurgien Dentiste*). Fauchard is credited as being the Father of Modern Dentistry, because his book was the first to describe a comprehensive system for the practice of dentistry, including a description of basic oral anatomy and function, operative and restorative techniques, and denture construction. His book also includes the statement that sugar derivate acids, such as tartaric acid, are responsible for dental decay. (7,8).

Dentistry had always been considered a lesser part of medicine, but by the end of the 18th century, it had begun to emerge as a discipline in its own right. In the late 1750's, the term 'dentist', borrowed from the French, started to be used in Britain to describe tooth operators. Claude Mouton, in 1746, describes a gold crown and post to be retained in the root canal. He also recommends white enameling of gold crowns for a more aesthetic appearance. The first lectures on teeth given at the Royal College of Surgeons, Edinburgh were by James Rae in 1764.

Before the first formal veterinary school was established in Lyons France in 1761, there were no standards or accountability for the veterinary profession. The first formal anatomy course for veterinarians was at the second veterinary school in Alfort, France. This was soon followed by similar schools in England, Germany, and other European countries. These schools emphasized equine care, but dentistry was not at the forefront of their curricula. Throughout the 18th century "bleeding" and "burning the lampas" were common professional practices. In his *Gentleman's Farriery* (1764), John Bartlet refers to E. G. La Fosse, farrier to the King of France, who had success using puffballs to stop bleeding in horses, a method used about 160 years previously by the German surgeon Felix Wurtz on human patients. These medicinal mushrooms (Apioperdon pyriforme and Calvatia gigantea) were still used by Native American folk medicine practitioners until the 20th century.

John Baker using the title, *Operator for the Teeth*, was the earliest medically trained dentist to practice in America. After emigrating from England, he set up a dental practice in Boston in 1765. After several years there treating hundreds of patients, he moved to New York where he claimed in a newspaper advertisement to have treated upwards of two