Proceedings of the American Association of Equine Practitioners - Focus Meeting

Focus on Dentistry

Albuquerque, NM, USA – 2011

Next Focus Meetings:

July 22-24, 2012 - Focus on Hind Limb Lameness
Oklahoma City, OK, USA

September 6-8, 2012 - Focus on Ophthalmology
Raleigh, NC

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Dental Anatomy

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Dental Embryology

In the equine fetus, a band of epithelium along with the underlying mesenchyme infolds into the primitive oral cavity and forms a series of buds that will later develop into the deciduous teeth. A further, smaller protrusion develops off of the incisor and premolar deciduous teeth buds, which becomes buds of the permanent teeth. Clinically important details from dental embryology include the fact that the tissue initiating tooth formation is epithelial in origin and consequently, animals with generalised epidermal dysplasia have absent or dysplastic teeth in addition to possibly having dysplasia of their skin, tail, mane and their hooves. Also of clinical importance is that if an incorrect number of buds i.e. too few or too many develop, the animal will subsequently have anodontia (no teeth) if no buds develop; hypsodontia if a reduced number of buds are present or supernumerary teeth, if an increased number of buds develop. Within the dental buds, ameloblast (epithelial-derived) cells develop which produce enamel, along with two types of mesenchymal cells, i.e. odontoblasts which produce dentine and cementoblasts which produce cement(um). Interaction between the ameloblasts and odontoblasts initiates tooth formation.

The alignment of these buds is also critical. If the dental buds are displaced, the teeth that subsequently develop from them will also be displaced. This reason for dental displacement is additional to the more common cause, i.e. dental displacement caused by overcrowding of teeth during eruption. The epithelial-derived component of the dental bud forms the enamel organ and this structure determines the final shape of the teeth. In equine teeth, in contrast to brachydont (e.g. human) teeth, the enamel organ has marked infolding of its periphery, especially in mandibular cheek teeth as well as the single infundibulum (enamel infolding) present in incisors and the paired infundibulae in the upper cheek teeth. Developmental irregularities in the orientation, shape or size of the enamel organ will cause the enamel structure of the teeth and subsequently of the dentine and cementum to be abnormal, i.e. dysplastic. Genetic abnormalities of enamel, dentine and cementum proteins also cause dental dysplasia, but these have not been studied in the horse.

The blood supply to the developing tooth is derived from a fleshy structure termed the dental sac that surrounds it. It is now known that a blood supply also perforates the apical aspect of the infundibulum in young equine cheek teeth and these apical infundibular blood vessels may remain for a couple of years after dental eruption.

Equine Dental Tissues

Enamel

Equine enamel is in general similar to enamel in other species, being a hard and dense substance composed of 96-98% minerals. Because it is inert and acellular once formed, it is then basically a
dead calcified material and cannot repair itself. The structure of equine enamel has been described by Kilic et al. who have divided it into two main types. Equine type 1 enamel which is the main constituent of the cheek teeth, consists of parallel rows of prisms lying between parallel, dense interprismatic plates of enamel (Fig. 1). This type of enamel has evolved to be extremely hard, to allow for the very prolonged mastication of fibrous food (up to 18 hours per day) by the horse. However, because of the parallel orientation of its prisms and interprismatic enamel it is more susceptible to developing fractures than the other main type of enamel, i.e. Equine type 2 enamel. The latter type of enamel solely consists of prisms (rounded on cross section) which are oriented in three directions. It has a “spaghetti-like” appearance as the prisms interweave with each other in the 3 different planes. This type of enamel is softer than Equine type 1 enamel but because of the absence of any parallel planes within its structure, it is very resistant to cracking. It is therefore not surprising that the equine incisors are largely composed of Equine type 2 enamel because they are relatively small and have little support from the adjacent incisors, yet can pull fibrous food vigorously for prolonged periods each day without developing spontaneous fractures (unlike the cheek teeth).

![Figure 1. Electron microscopy of Equine Type-1 enamel.](image)

Enamel is produced by the ameloblasts at the apical aspect of the developing teeth and when the enamel is fully developed (usually about the time of dental eruption) the ameloblasts die off, and as noted no further regeneration of enamel can now occur. Later on in dental development and following tooth eruption, cementum is deposited at the apical aspect of the enamel and these enamel free areas are the true roots of the equine teeth. Another difference in equine as compared to brachydont teeth is the fact that the (shiny) enamel on the sides of equine clinical (erupted) crown is usually not visible because it is covered by a layer of dull, often stained cementum, an exception being the rostral/vestibular aspect of the incisors where the cementum becomes worn away while prehending food, revealing the underlying shiny, white enamel.

**Enamel Infolding and Infundibular Enamel**

The cheek teeth have evolved to become very efficient at grinding tough fibrous food and instead of having a single layer of enamel around the periphery of the cheek teeth (like incisor teeth) the lower cheek teeth in particular have very extensive infolding of enamel that protects the softer cementum and dentine. du Toit et al. have shown that the ratio of peripheral enamel length to tooth perimeter in mandibular cheek teeth is 1.87 (indicating much infolding of enamel),
compared to a value in maxillary cheek teeth of 1.48; however, the maxillary cheek teeth also have infundibular enamel that compensates for their reduced infolding.¹ Normal infundibulae can be up to 89 mm long in 4-year-old horses to as low at 2 mm in 30-year-old horses which on average infundibular length being a mean of 82% of the total dental crown length; however, in individual cheek teeth and horses, they may be relatively much shorter.¹ Thus with age either one or both infundibular can wear out (often in the 09 or 10) causing the adjacent unsupported primary and secondary dentine to wear very fast and the tooth to become hollow. Eventually this is a feature of most old teeth and this form of wear has been termed senile excavation. Likewise the degree of infolding present on the periphery of teeth decreases more apically and thus with age a more peripheral rim of enamel without deep enamel infolding can be present in mandibular cheek teeth that also become hollowed out.

_Dentine_

Dentine is the main component of the tooth and this mesenchymal tissue is continually secreted for the life of the tooth by odontoblasts that reside on the periphery of the pulp. Prior to dental eruption odontoblasts lay down what is termed primary dentine which is the (very regularly oriented) outermost layer of dentine that is attached to the peripheral enamel at the amelo-dental junction. Later during dental eruption in the horse these odontoblasts lay down regular secondary dentine that is of similar appearance to the primary dentine in that the dental tubules are straight. However, secondary dentine is more porous than primary dentine and absorbs food pigments – becoming darker (e.g. the “dental stars” in incisors) than the adjacent primary dentine. The next phase of dentinal deposition even in normal teeth that have not been exposed to a noxious stimulus, is the deposition in the more central areas of the pulp of irregular secondary dentine which as its name implies has dental tubules oriented irregularly in various directions.⁵ In older horses this irregular secondary dentine will fully replace the subocclusal pulp. Over a 20 year lifespan of an equine cheek tooth, secondary dentine will gradually encroach on the 2 mm wide pulp horn laying down 1 mm of secondary dentine on each side until the pulp horn is fully obliterated, whereas at the same time in a tall cheek tooth, up to 100 mm of secondary dentine may need to be laid down subocclusally in order to prevent exposure of the pulps caused by dental attrition (normal dental wear).⁶ This finding indicates that there is a specific stimulation for secondary dentine deposition in the subocclusal pulp originating from the occlusal aspects of the teeth.

If pulps are exposed to a noxious stimulus, a further type of dentine termed tertiary dentine can be deposited. There are two types of tertiary dentine, including reparative tertiary dentine that is laid down if odontoblasts survive the pulpar injury, for example following dental fracture or pulpar exposure. In the absence of any viable odontoblasts following a pulpar insult, connective tissue cells (also of mesenchymal origin) within the pulp can change into odontoblast-like cells and lay down what is termed reactionary tertiary dentine to seal off the underlying pulp from the oral environment or other noxious stimulus.⁷ Because of the intimate relationship of dentine and pulp they are sometimes termed the dentino-pulp complex.

_Peripheral Cement(um)_

Cement is a cream coloured calcified tissue, with similarities to bone. In brachydont teeth cementum lies only subgingivally and its function is to anchor periodontal ligaments and thus
secure the tooth to the alveolar bone. A more detailed discussion of the periodontal ligament is presented in these proceedings by Dr. Stazyzk. The prolonged eruption of equine teeth causes the cementum to continually ascend onto the clinical crown where it covers the enamel surface of the tooth with a variable thickness. Cementum thickness is greatest in the mandibular cheek teeth where the deep peripheral enamel infoldings are filled with and surrounded by thick cementum. Unlike brachydont teeth, cementum forms a major structural component of equine cheek teeth, giving it mechanical strength and wear resistance. Mitchell et al have also shown that the thickness of equine cementum - which is physically restricted when the tooth lies within the bony alveolus - increases immediately after the tooth erupts from the limitations of the alveolus. They have also shown that this recently erupted cementum on the clinical crown is viable, with blood vessels running some millimetres from the periodontal ligaments to this recently deposited, thick cementum. This cementum also contains viable cementoblasts and cementocytes.

At the end of enamel development the apex of the tooth cannot be called a true root. However, after eruption, much cemental deposition occurs to form the true roots and this deposition continues over the life of the tooth, until it becomes loose or is fully worn away. Unlike brachydont teeth, the subgingival cementum covering the reserve (unerupted) crown of the equine tooth (coronal cementum) is constantly remodelling as the periodontal ligaments are continually reformed and gradually extract the tooth into the oral cavity as further described by Dr Stazyzk in these proceedings. Once the cementum rises above its vascular supply (a few mm above the gingival margin) it now is essentially a dead tissue (just like enamel) with no ability to repair itself. This peripheral cementum can later develops cemental caries.

**Infundibular Cementum**

The single infundibulum of the incisors and both infundibulae of the cheek teeth contain infundibular cementum. Defects in cemental filling are termed infundibular cemental hypoplasia and a high proportion of cheek teeth have their infundibulae incompletely filled with cementum. Inexplicably the 09 position has much more infundibular cemental hypoplasia than any other Triadan position. These infundibular cemental defects are so common in equine cheek teeth (especially the 09’s) that they could almost be termed a physiological feature. However, these cemental defects can later get filled with food and subsequently develop caries that can cause clinical disease. It was previously believed that the only blood supply to the infundibulum came from its occlusal aspect from the dental sac vasculature, but as noted it has recently been shown that blood vessels penetrate the apical aspect of the teeth. Consequently, infundibular cemental deposition could continue following eruption, but inexplicably does not in many (especially Triadan 09) cheek teeth.

Once the overlying tooth has erupted and the cap and underlying dental sac is lost, the blood supply to the occlusal aspect of the permanent 06, 07 and 08 is lost. Many cheek teeth have a fine central defect in their infundibular cement which was the site of this dental sac blood vessel. Many infundibulae are curved and have cemental defects that can be over 70 mm above the occlusal surface. With the limited opening of the equine oral cavity, it is difficult if not impossible to access these defective areas of the infundibulae from the occlusal aspect, using straight drills.
**Dental Pulp**

Little is known about the histology of equine pulp but it appears to be more cellular and metabolically active than the pulp of brachydont teeth. This is not surprising considering the continual eruption and occlusal wear of hypsodont teeth over the horse’s life and consequently, the continuous need to lay down subocclusal secondary dentine to prevent pulpar exposure. Because of the high metabolic activity of equine pulp over a prolonged period it has a generous blood supply - unlike mature brachydont teeth. Therefore with pulpar exposure such caused by a dental fracture, when the pulp is exposed to the oral environment, the subsequent inflammation and oedema that develops in the pulp does not necessarily compress its large vasculature and cause pulpar ischaemia and death, as often occurs in brachydont teeth. With survival of the pulp, tertiary dentine can seal off any areas of exposed pulp, and the tooth then can continue to be viable.

The gross anatomy of the pulp chambers of the equine teeth was described by Dacre (2005) who showed a single pulp horn to be present in the incisors, canines and 1st premolar (wolf tooth). In younger horses, the pulp horn of incisors is displaced labially by the infundibulum, whilst in mature teeth, the apical aspect of the pulps are compressed laterally. In general, each cheek teeth has five pulp horns except for the rostral cheek tooth (Triadan 06) and the caudal (Triadan 11) cheek tooth. The 06’s have an additional pulp which is termed the 6th pulp which lies on the rostral, triangular-shaped aspect of this tooth (Fig. 2). This 6th pulp horn is prone to pulpar exposure or thermal injury if the (fully unvalidated) procedure of bit seating is aggressively performed. The caudal mandibular cheek teeth (311, 411) also have an additional pulp termed the 7th pulp, and mature maxillary 11’s have two additional pulp horns (7th and 8th). Dacre et al developed a numbering system for these pulps; however, this pulp numbering system was soon superseded by that of du Toit who developed a simpler system with the 1st pulp always lying on the rostro-buccal aspect of the tooth and the 2nd pulp on the caudo-buccal aspect of the tooth. The 3rd pulp is on the rostro-lingual aspect of the tooth. (Fig. 3).

![Figure 2. Transverse section of a mandibular cheek tooth showing the additional (6th) pulp horn on the left side.](image-url)
Figure 3. Pulpar anatomy of cheek teeth du Toit et al 2009, showing maxillary teeth on top row and mandibular teeth on bottom row. The teeth on left are the 06s, the central teeth represent the 07s-10s and the 11s are represented on the right.

Thickness of Subocclusal Secondary Dentine in Cheek Teeth

Until recently, there was limited information concerning the thickness of the subocclusal secondary dentine that protects the underlying cheek teeth pulp from exposure to the oral cavity. In the 1940’s Becker, suggested that 1 cm of secondary dentine was present above all pulps but recent work has shown much variation in the thickness of subocclusal secondary dentine with values of 10.8 mm and 9 mm reported for mandibular and maxillary cheek teeth, respectively. It has also been shown that the thickness of secondary dentine slightly decreases with age indicating that over time, teeth wear slightly faster than dentine is deposited. In particular this work has shown some variation even within normal teeth from 2 mm to 33 mm in depth as well as much variation between different teeth. The practical significance of this finding is that great care must be made when mechanically floating equine teeth to ensure that the pulp is not exposed or thermally damaged by the heat from such equipment which is not water cooled (currently the near-norm for equine dental equipment).

With recognition of the significance of equine cheek teeth diastemata over the past decade, and the subsequent widespread use of diastema widening to treat this disorder, the relationships of the occlusal aspects of the pulp to the mesial and distal margins of the teeth has also become very significant, in order to ensure that the pulps are not directly exposed or thermally damaged at these sites during diastemata widening. Recent work by Bettiol and Dixon has shown much variation in the distance between the pulp and the mesial or distal tooth margin which varies from 1.3 to 10.8 mm. In particular, it has been shown that the pulp horns (and thus pulp) at the distal aspect of the tooth are much closer to the interproximal space than are the pulps at the
mesial aspect of the tooth. The practical significance of this is that during diastemata widening, just 2-3 mm of dentine should be removed from any tooth and most should be removed from the mesial aspect of the tooth most distal to the diastema. Depending on the direction of rotation of the diastema burr used, and which side of the mouth is being treated, this can take some considerable skill.

Pulp and Dentine in Overgrown Teeth

As noted, nearly 100 times more secondary dentine is laid subocclusally than on the walls of the pulp horns providing evidence that occlusal stimulation is the main driver for deposition of subocclusal secondary dentine. Therefore in the absence of any occlusal stimulus, for example in a tooth whose opposite number has been lost, or where there is much reduced occlusal contact, for example in a tooth opposite a fractured, dysplastic or worn tooth (that contains less than a normal amount of enamel) there will be no or reduced stimulus for laying down subocclusal secondary dentine. This theoretically should cause the subocclusal dentinal thickness to become thinner than normal. However, this is counterbalanced by the fact that reduced or no attrition (normal wear) is taking place on the surface of the poorly opposed or unopposed tooth.14

The combined effect of these two opposing factors is that in general, there is a net increase in thickness of subocclusal dentine in overgrown teeth. However, whilst most overgrown teeth have such increased thickness of subocclusal dentine, this can vary between horses and even between individual pulp horns in the same overgrown tooth. Some overgrown teeth may even have thinner than normal subocclusal dentine. A take-home message from this work is that if overgrown teeth are reduced to the level of the adjacent normal teeth, this may cause pulp exposure. Even if pulp exposure does not occur during this procedure, the grinding away of such a large amount of dentine with un-cooled dental equipment could cause thermal damage to the underlying pulp. If the occlusal aspect of the pulp is thermally injured, it can no longer lay down secondary dentine and when the existing secondary dentine overlying this pulp is eventually worn away by normal wear, pulpar exposure can then occur and may lead to pulpar infection and even loss of the tooth.14

The Occlusal Surface

Immediately after eruption, the occlusal aspect of the tooth is covered by the soft-tissue dental sac, and when this is soon worn away, it exposes a tooth that is completely surrounded by cementum even on the occlusal surface. This is the primary occlusal surface but after a very limited amount of mastication this occlusal cementum will be worn away revealing the permanent occlusal surface which is a sandwich of different calcified dental tissue with cementum lying peripherally to enamel and (primary) dentine lying most centrally. With further dental eruption and wear, the subocclusal aspect of the pulp horn (beneath the primary dentine) becomes filled with secondary dentine. As the tooth later wears away, secondary dentine is then exposed on the occlusal surface. Enamel is by far the hardest tissue in the body and the peripheral (and infundibular on the upper teeth) ridges of enamel wear slowest and thus protrude on the occlusal surface, with the softer cementum and dentine being worn more quickly. This layering of hard but brittle enamel between the softer but flexible dentine and cementum creates a biological “safety glass” that helps prevent enamel and thus dental fractures.
Pellicle

Within minutes of being brushed, the enamel surface of a human tooth will develop an organic covering consisting mainly of mucopolysaccharides and glycoproteins from saliva, and oral bacteria to form what is termed as a pellicle. All horse teeth have an organic pellicle. If this organic layer becomes thicker, containing many bacteria it can eventually be termed dental plaque and has been suggested in the horse that a cut off point of a thickness of <10µm should differentiate between pellicle and plaque. In the normal horse the ingestion and mastication of coarse forage, that is low in soluble carbohydrates for very prolonged periods acts as a natural toothbrush and therefore plaque is not present on normal equine teeth except in the interdental areas as recently shown by Cox et al 2011.

Occlusal Physiology

A high level of normal attrition (wear) occurs on the surface of equine cheek teeth because of the low calorific content of their largely cellulose diet A study in Britain showed that horses graze for about 13 hours a day in the summer when the grass is most nutritious to over 16.5 hours a day in the winter when the grass is less nutritious (M. Booth 1996 personal communications). However, in poor winter weather, horses may graze for up to circa 20 hours a day, may graze lower and thus get more abrasive silica on their teeth and even eat a more woody type diet, with all of these factors increasing the attrition on their teeth, (M. Booth 1996 personal communications). Whilst masticating hay, a horse has between 58-66 chews per minute, taking approximately 4200 chews for every kg of dry matter. When at grass, horses chew much faster (100-105 chews per minute). Thus it can be seen in addition to eating for example up to 20 hours per day horses can have over 6000 chewing motions per hour on their teeth, all leading to the high rate of dental attrition of their teeth.

Gross Anatomy of the Equine Teeth

Nomenclature

In many brachydont species, the teeth form a full arch i.e. a continuous row of teeth from a caudal molar to the caudal molar on the opposite side of the mouth. The terms arcade and arch are thus suitable for this type of dentition. However, in the author’s opinion, with the horse where there is a straight row of six cheek teeth on each side that is separated by the physiological diastema (“bars of the mouth”) from the canine tooth (if present) and incisors, the term cheek teeth row is more appropriate. For the same reason terming the more rostral aspect of the cheek teeth row as medial (mesial) and the more caudal aspect as distal does not make anatomical sense in the horse, and the more anatomically accurate terminology are rostral and caudal. The equine incisors do form a true arch and the terms distal and mesial are applicable for these teeth.

Incisor Development

To describe the deciduous teeth using the Triadan system, an additional 4 is added to the first number. Using this system the deciduous 01’s (first incisors) are 501,601, 701, and 801; the deciduous 02s are 502, 602,702, and 802 and the deciduous 03’s are 503,603, 703, and 803. The
deciduous 01s erupt during the first week of life, the 02s at 4-6 weeks and the 03s at 6-9 months of age. The deciduous incisors are whiter and have wider and shallower infundibulae than the permanent teeth that normally erupt on their lingual aspect. They also erupt deep below the true roots of the deciduous teeth and cause their physiological resorption, as well as physically loosening them.

Ageing by Dentition

The eruption of the deciduous and permanent incisors can be used to relatively accurately age horses up 5 or 6 years of age. Beyond that time, the features which have traditionally been used for ageing such as the presence of occlusal secondary dentine (“dental stars”) and the disappearance of the infundibulae have now been scientifically shown to be unreliable. Many horses have very thin subocclusal secondary dentine and thus secondary dentine appears on the occlusal surface much earlier than traditionally believed. Some horses have much deeper infundibulum than what has been regarded as “standard” and thus their incisor infundibulae lasts for much longer than commonly accepted. Likewise the appearance of the “7 year hook” and “Galvayne’s groove” are unreliable indicators of age in some horses. For these reasons the ageing of horses by the morphological appearance of their incisors or cheek teeth after 6 years of age is inaccurate in many horses. If such ageing is attempted, its limitations must be fully acknowledged.

Canine Teeth

Deciduous canine teeth can occur in horses but they are vestigial, often only detected radiographically and they usually do not fully erupt. In female horses the canine teeth usually do not develop and if they do, they are vestigial in size and shape. The canine tooth usually fully develops only in male horses, usually erupting between 4-6 years of age although occasionally (including in miniatures) they may not erupt for a further year or so. Unlike all other classes of equine teeth, the canines are not in direct opposition with each other; the mandibular canine being more rostrally positioned than the maxillary canine. Although they have relatively small clinical crowns (1-2 cm in height), they can have a very long reserve crown (up to 7 cm in length) lying in the alveolus. The canine teeth have vertical clinical crowns, but the reserve crown usually lies horizontally in a caudal direction. It is not absolutely clear whether canine teeth are brachydont or hypsodont and it may be that they are somewhere between these two categories. Whilst some eruption of the canine tooth may occur throughout the life of the horse, many older horses have very long reserve crowns of their canine teeth and clarification of the nature of canine teeth is required.

The canine teeth are convex on their lateral aspect and concave on their lingual (medial) aspect. In many horses the single pulp cavity of the canine may lie less than 1 cm below the tip (occlusal aspect) of the clinical crown. Some operators consider it fashionable to reduce the clinical crown of the canines, purportedly to prevent contact with the bit; injury to other horses when fighting and to even prevent damage to the hands of veterinarians when performing dental examinations. These are all very dubious reasons to grind down perfectly healthy structures. If the canine teeth are reduced too much their pulp will be exposed, a consequence being that if the horse cannot seal the exposed pulp with tertiary dentine, the teeth will likely develop apical infection, general
periodontal disease and may eventually become painful and loose. A very important point when reducing any type of equine teeth that dentine is totally avascular. If any hint of pink occurs during a dental reduction procedure this means that the pulp has already been exposed and that dried blood from the exposed pulp is now covering the adjacent dentine.

**First Premolar (Wolf Tooth) (Triadan 05s)**

The Triadan 05 teeth erupt at about 1 year of age and have a reported prevalence of 24% in females and 15% in males. However, in older horses, a much lower prevalence of wolf teeth is present that may be due to loss of wolf teeth when the deciduous 06 (cheek teeth) are being shed at about 2.5 years of age. The Triadan 05’s appear to be brachydont teeth, but like canine teeth, they have not been fully classified in the horse. The presence of wolf teeth in individual horses has traditionally been claimed to cause a range of illnesses, including blindness to every possible behavioural and bitting problem! In European countries, many older horses that have been ridden to the highest competitive standards still have their wolf teeth, whereas in other countries, their presence is regarded as being incompatible with use of a bit.

If a wolf tooth is very large and protruding into the bars of the mouth; is displaced; and particularly if it is a mandibular wolf tooth, it may then cause bitting problems. In such cases, their extraction is justified. This procedure will invariably cause some discomfort to the horse for a few days. For most other horses with normal sized and positioned wolf teeth, there is no objective evidence that their extraction is of any benefit to the horse. Objective research is needed in this area so that veterinarians who consider that wolf teeth do not need to be extracted in some horses are not treated as if they do not know the “basic rules” of dentistry.

**Cheek Teeth**

**Nomenclature**

The term cheek tooth is a useful term to describe premolars 2, 3 and 4 and the three molars. Traditionally these 6 teeth have often been termed “molars” and many equine dental instruments still have this association, i.e. “molar cutters” or “molar shears” but this is an inaccurate term.

**Development**

Shortly after birth the 12 temporary premolars (Triadans 6, 7 and 8’s) erupt (Fig. 4) and these teeth are similar in cross section to the underlying permanent cheek teeth which develop later. In the neonatal foal the 3 deciduous cheek teeth occupy the full length of the mandible and maxilla. With jaw lengthening, there is now room for the 4th cheek tooth (Triadan 09) to erupt at one year of age. By 2 years of age there is room for the 5th cheek tooth (Triadan 10) and by 3-4 years of age (when the skull is almost at its full size) there is room for the 6th cheek teeth (Triadan 11) to erupt.

Radiographically, the developing cheek tooth can initially be seen as a rounded radiolucent structure. It later develops calcification of the vertical enamel folds and later on increasingly becomes morphologically similar to the mature cheek tooth. As the permanent tooth grows it
causes both physiological resorption of the apex of any overlying tooth, and physical displacement of it into the oral cavity, where the thin deciduous tooth remnant is known as a “cap”. As noted earlier the permanent tooth is covered by a dental sac which nurtures the peripheral cementum and the infundibular cementum in the upper cheek tooth. As soon as the underlying “cap” is dislodged, the soft tissue of the dental sac is immediately worn away and no further nutrition to the occlusal aspect of the erupting tooth is possible. It has been stated that premature extraction of the upper caps removes the blood supply to the infundibulum and this is a cause of infundibular cemental defects in the upper cheek teeth. However, as the upper 09’s alone contain 50% of all severely hypoplastic infundibular and the 09’s have no deciduous precursors, this theory seems invalid for most cheek teeth.

**Clinical Crown Shape and Orientation**

The first and last cheek teeth are triangular in shape and the remaining cheek teeth are rectangular shaped in the mandible and square in the maxilla. They are normally tightly compressed together at their occlusal surface at the interdental (interproximal) sites. This occlusal compression is due to the rostral angulation of the 11’s and to a lesser extent the 10’s that push their clinical crowns in a rostral direction and due to the caudal angulation of the clinical crowns of the 06’s (is normally shorter than the other cheek teeth) which compresses the occlusal aspect of the cheek teeth caudally (Fig. 5).

![Figure 5. Orientation of the cheek teeth clinical and reserve crowns in a young horse.](image)

Figure 4. Mandible of a neonatal foal showing the 3 deciduous cheek teeth in each row.

This caudal angulation of the 06 clinical crown was an evolutionary development in the horse when they developed the physiological diastema, otherwise all the cheek teeth would be tilted forward by the rostral pressure of the clinical crowns of the 10’s and 11’s. It is believed that this evolutionary development occurred simultaneously with the elongation of the horse’s head that may have been to allow it to both graze and observe for predators. Some diagrams of cheek teeth longitudinal and transverse sections are shown in Figs. 6-8.
Figure 6. Longitudinal and transverse section of a maxillary cheek tooth. The apical aspect of tooth is to the top of image.

Figure 7. Longitudinal and transverse section of a mandibular cheek tooth. The occlusal aspect of tooth is to the top of image.
**Occlusal Transverse Ridges**

In addition to the previous noted irregularity of the occlusal surface due to the differential wear between the hard enamel and the two softer calcified tissues, the occlusal surface of horses have a series of transverse protuberances that have been termed *transverse ridges*. These can be more technically described as styles or ridges which are linear elevations on the surface (occlusal or peripheral of a tooth). On the occlusal surface they can be due to the presence of interconnected cusps (elevations of the occlusal surface). Horses usually have between 11 and 13 transverse ridges that can vary in size between individuals, breeds and with age. These ridges are sometimes very pronounced on the caudal cheek teeth of younger horses and may be up to 7-8 mm high in such cases. These ridges have evolved to increase the occlusal surface area to increase the efficiency of grazing and they are a *normal* feature of horses. Using pseudoscience, recently some lay people have somehow come to the conclusion that despite their 50 million years of evolution, these ridges are not beneficial to the horse and should be rasped off, in the belief that they will improve rostro-caudal mandibular movement, which they somehow believe is of great advantage to the horse. If all these ridges are of similar size, even if very tall, they should be regarded as normal features which should not be reduced by veterinarians.

**Figure 8.** Longitudinal sections of a young maxillary cheek tooth showing two pulp horns and a long infundibulum with cemental defects.
Peripheral Ridges of Maxillary Cheek Teeth

Ridges also occur on the peripheral aspect (buccal) of the upper cheek teeth, usually consisting of two prominent vertical ridges and often a smaller, less prominent caudal ridge. The height and shape of these ridges along the buccal aspect of the tooth varies greatly between individual horses. Horses with very prominent and sharp ridges are prone to develop sharp overgrowths on the occlusal aspect of the ridges that in particular, can cause ulceration of the caudal buccal mucosa particularly opposite the Triadan 10s and 11s. Such sharp ridges can occur in horses that have never been fed concentrates (hard food) and the influence of genetics, domestication and diet on the development of buccal ulcers in such cases it is unclear.

Root Development

Because of their hypsodont nature, equine cheek teeth can be of great length (i.e. 10 - 11 cm in larger horses) and these teeth gradually erupt at a rate of 2-3 mm per year over the life of a horse. As noted, cementum is deposited on the apical aspect of the enamel, forming the true roots a year or so following eruption and these roots gradually increase in length over the life of the tooth. The upper cheek teeth have two well defined buccal roots, (rostral and caudal) and a less defined longitudinal palatal root that is difficult to discern on radiographs. The lower cheek teeth have two (rostral and caudal) roots except the Triadan 11s that have 3 roots.

Sites of Reserve Crowns

All the mandibular teeth are by definition embedded in the mandible with the 10s and 11’s lying deep to the masseter muscles. The upper 06’s and 07’s, and in some horses the rostral aspects of the 08’s, lie embedded in the maxillary bone with relationships to the nasal cavity on their medial aspect and the maxillary bone laterally. The alveoli of the upper 08s and 09s normally lie in the rostral maxillary sinus which is separated by a bony septum from the caudal maxillary sinus which normally contains the alveoli and reserve crowns of the maxillary 10’s and 11’s. In the younger horses the maxillary sinuses are almost filled with the above alveoli and reserve crowns but with age (and continued dental eruption) the apical aspect of the alveoli gradually retracts from immediately beneath the infra-orbital canal in the young horse to up to 5-6 cm below this level in the older horse. Consequently, the maxillary sinuses become much larger in volume with age. The rostral angulation of the clinical crowns of the Triadan 10’s and 11’s and the caudal angulation of the 06s decrease as the tooth is extruded and with age, these teeth become more vertical in position. The cheek teeth also drift rostrally with age as can be noted on radiographs of the older horse.20

Shape of Cheek Teeth Rows

Although the cheek teeth are described as being in rows, the maxillary row in particular is not straight, being convex on its buccal aspect. A practical significance of this being that to reduce overgrowths on the buccal aspect of the caudal two maxillary cheek teeth a reverse angled rasp must be used and similarly, an angled rasp must also be used on the 06’s in order to reduce overgrowths. Equine cheek teeth also taper inwards from their occlusal to the apical aspect and thus become shorter in a rostral to caudal direction with age. A consequence of this along with
the loss of angulation of the rostral and caudal cheek teeth is that abnormal space termed a diastema develops between the cheek teeth in the senile horse that is termed *senile diastemata*.

*Figure 9. Right lateral view of an equine skull showing very prominent vertical ridges on the maxillary cheek teeth, minimal transverse occlusal ridges and a relative prominent curve of Spee.*

**Curve of Spee**

Another variable feature of the equine occlusal surface is a varying upward slope of the caudal mandible/maxilla (containing the caudal 2-3 cheek teeth) that is termed the curve of Spee. This dorsal curvature can be marked in some horses and is said to be most prominent in horses with convex faces such as Arabian horses but it can also occur in larger draft horses even those with a Roman-nose i.e. a more concave appearance of the face. If marked, the dorsally-sloping lower 10s and 11s can be mistaken as overgrown teeth and an ill-informed operator could reduce these teeth and cause pulpar damage. The fact that these teeth are not overgrown can be judged by assessing the height of clinical crown between the 08’s, 09’s, 10’s and 11’s. No matter how much upward curvature there is on the jaw, if the same height of clinical crown is present on these caudal teeth as is present on the rostral teeth, this indicates that there is no overgrowth of the caudal teeth. Even if true overgrowths were present, dental shears should never be used because of the variable and possibly thin layer of occlusal secondary dentine present in some horses.

**Anisognathia**

The maxillary cheek teeth rows are further apart than the mandibular rows and this difference is a median of 23% in horses.21 In donkeys, du Toit has shown similar values but the disparity of the distances between the upper and lower cheek teeth rows is greater caudally than rostrally. 4

**Occlusal Angulation**

Until relatively recently it was believed that the occlusal surface of cheek teeth rows had an angle of 15%, sloping in a medial to lateral direction. The consequence of this belief was that clinicians would examine the rostral mandibular cheek teeth and then see higher angles in the more caudal mandibular cheek teeth and consequently (using motorised equipment) mistakenly reduce the angles of the caudal teeth to make them similar to those of the rostral teeth. More
recent work has shown normal mandibular cheek teeth to have angles of circa 15° in the 06’s that increase up to 32° in the 11’s. In contrast, the maxillary cheek teeth have a higher angulation more rostrally for example 19° in the 06’s that decreases to about 9° in the 11’s. Therefore it can be seen that it is totally inappropriate to change all cheek teeth angles to 15° or to try and equalise the angles at the front and back of the mandible and maxilla or try to make the maxillary and mandibular angles similar. The angles of the teeth are governed by developmental factors (Fig. 10) and later by the type of diet and length of time masticating and degree of lateral motion of the mandible during this mastication. Likewise with painful disorders the full biggest lateral excursion will not occur with the mandible and higher angles (>45°, i.e. shearmouth) will develop on or both sides of the jaw that are not masticating normally.

Fig 10. Neonatal foal showing angulation of the recently erupted cheek teeth.

References


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