Anatomy, physiology, ageing & nomenclature for equine dentistry.

Dr Oliver Liyou BVSc (Hons1) MACVSc (Eq Dent)

The Chewing Cycle and Function of the Mouth

Horses being grazing herbivores are naturally meant to eat grass for between 14 and 18 hours per day.

Unlike ruminants, horses chew the food only once and do not regurgitate it. Thus it is important that they crush and shred it into small enough pieces to maximise the surface area to volume ratio of the feed, to allow the digestive enzymes and bacterial fermentation to initiate the extraction of nutrients from the feed particles.

In the mastication process, the horse uses its upper and lower lips and olfactory system to select the grass to be eaten, test it, and then pull it into the mouth between the incisor teeth. The horse then uses its incisors to cut and rip the grass until the rostral portion of the mouth is filled with food.

The tongue and cheeks then move the grass back to the molar arcades, where the grass is crushed and processed by the molar teeth arcades. It is processed into a spindled spiral shape which is moved back by the tongue. The tongue squeezes the spindle against the palatine ridges of the roof of the mouth, and moves it further back for further chewing or prepares it to be swallowed.

The masticatory muscles operate to move the mandible in essentially 3 phases for the chewing action – the opening, closing and the power stroke phase.

There also is some rostro-caudal movement of the mandible in the chewing cycle.

Lateral excursion is the movement of the mandible in the oval side to side direction.

As with all mammals, the whole process of mastication is very complex. So any interference of this through dental abnormalities, can lead to pain, which will cause slower and less efficient mastication of the feedstuffs, and thus less feed is ingested. Also, the effectiveness of the crushing of the feed may cause it to be swallowed prematurely, with a relatively higher SA:Volume ratio, and so will not be digested, and the nutrients absorbed, to the highest possible level.

Inadequate grinding up of the feed stuffs into small pieces can predispose the horse to weight loss, colic, choke and diarrhoea.

The rate of eruption of reserve crown is directly influenced by the amount of attrition of the hypsodont tooth. Thus pastures high in silicates will lead to premature wearing out of the teeth. Similarly, if teeth are ground down excessively, the tooth will erupt faster and wear out faster.

The effects of domestication:

- With green grass, the horse will use maximal lateral excursion

- With dry grass, lateral excursion is reduced

- With grains and pellets, lateral excursion is much reduced. The analogy here is when humans eat lettuce versus eating peanuts.

With the reduced lateral excursion from eating grains, there is a more rapid development of sharp enamel points – on the buccal edge of the maxillary arcades and the lingual edge of the mandibular arcades.

The other problem arising from domestication is that when horses are not grazing, they are not using their incisors. Thus relative overgrowth of incisors can occur, which then leads to other pathologies. However this abnormality has been proven to be quite uncommon affecting less than 2 % of all domesticated horses, and it usually affects horses over 12 years of age. The likely reason for the low incidence of this problem is that the molars erupt into wear, whilst their reserve crown allows it. Also, incisor teeth wear faster than molars due to different types and hardness of enamel present.

Anatomy

- Notes supplied courtesy of Assoc Prof Gary Wilson

Innervation of the teeth and jaws

The trigeminal nerve [CN V] supplies the sensory innervation of the teeth through its maxillary and mandibular divisions. The innervation to the upper teeth is via the infraorbital nerve (a branch of the maxillary nerve). It traverses the infraorbital canal exiting from the infraorbital foramen. Branches of this nerve within the infraorbital canal enter the alveoli of the cheek teeth. This nerve is easily blocked with local anaesthetic.

The inferior alveolar nerve (a branch of the mandibular nerve) supplies the lower teeth. The nerve enters the mandible medially via the mandibular foramen and exits at the mental foramen. Branches pass from within the mandibular canal to the alveoli of the cheek teeth. This nerve can be blocked at the mandibular foramen.

Normal occlusion

The upper cheek teeth arcade forms a slight curve caudally whilst the lower arcade is straighter. The distance between the lower arcade is approximately 30% narrower than the upper arcade (= **anisognathism**). The chewing action of the horse combined with the anisognathism leads to the formation of inclined occlusal surfaces.

Normal incisor occlusion when viewed from the side shows the upper and lower arcades in perfect alignment at the rostral surfaces.

Malocclusions

The most common malocclusion in horses is parrot mouth (overshot bite). This is where the upper incisors are more rostral than the lowers. The incisor discrepancy is usually larger than that of the cheek teeth although the difference in the cheek teeth arcades is much more significant due to the development of rostral and caudal hooks.

The malocclusion where the lower incisors are more rostral is called undershot bite or sow mouth (occasionally called monkey mouth). This is more common in the smaller ponies.

If the mandible is more than 30% narrower than the maxilla, shear mouth will develop. In this condition, the upper cheek teeth form excessive buccal overgrowth and the lowers excessive lingual overgrowth. With time the condition worsens.

All of these malocclusions are thought to be inherited conditions.

Dentition:

It is impossible to comment on the dentition of the horse if you do not even know how many teeth the foal or adult horse are supposed to have and when each of these teeth erupt.

<u>Dental formulae:</u>

Deciduous 2 x (i 3/3, c 0/0, p 3/3) = 24

[Deciduous 2 x (i 3/3, c 1/1, p 3/3) = 28 is more correct as horses have deciduous canines which do not erupt through the gums due to their extremely small size]

Permanent 2 x (I 3/3, C 1/1, P 3[or 4]/3, M 3/3) = 40 [or 42]

Note: Canine teeth often absent in mares; lower 1st premolar may be present in some horses

Eruption times:

Deciduous	1st incisor	birth or 1st week of life
	2nd incisor	4 - 6 weeks
	3rd incisor	6 - 9 months
	premolars	birth or 1st 2 weeks of life
Permanent	1st incisor	2.5 years
	2nd incisor	3.5 years
	3rd incisor	4.5 years
	canine	4 - 5 years
	P1 (wolf tooth)	5 - 6 months
	P2	2.5 years
	P3	3 years (lower P3 may erupt 2.5 yrs)
	P4	4 years (lower P4 may erupt 3.5 yrs)
	M1	9 - 12 months
	M2	2 years
	M3	3.5 - 4 years

Order of eruption of permanent cheek teeth:

M1; M2; P2; P3; M3; P4

This order of eruption can lead to impaction of P4 (i.e. 3rd cheek tooth) due to angulation of molars and insufficient space between crowns of P3 & M1.

Incisors

The occlusal surface has a deep enamel invagination (infundibulum) partially filled with cementum. With attrition, the infundibulum becomes smaller (& more lingual) and a "dental star" appears labially (= on the lip side). This dental star is just secondary dentine formed to protect the pulp as the tooth wears.

Cheek Teeth

Includes P2 to M3.

These teeth have a complex pattern of enamel with invaginations filled with cementum. The upper cheek teeth have two longitudinal grooves in the buccal (outside) surface of the crown. The resultant three ridges terminate in sharp points at the dental table. The enamel infoldings of the upper cheek teeth result in a dental table that resembles the shape of the letter “B” with two infundibulae within the “B”. The lower cheek teeth have only lateral infolding of the enamel and no infundibulae.

The roots of the cheek teeth are short compared with the length of the crown. As the reserve crown erupts, the roots become longer. Because of the relative size of the teeth, the bone plate on the buccal aspect (cheek side) of the roots and reserve crowns is thin.

The upper cheek teeth have 3 roots (2 small buccal & 1 large palatal). The roots of 3rd - 6th cheek teeth lie in the maxillary sinuses. The first upper cheek tooth is triangular in shape, as its rostral surface does not contact another tooth.

The lower cheek teeth have 2 roots except for M3 (which usually has 3 roots).

Wolf teeth

These are the first premolars and may or may not be present in the maxilla. They are occasionally present in the lower jaw as well.

The position and shape of the wolf teeth is variable. The root structure may be quite significant and usually only one root is present, although wolf teeth with two or three roots can occur.

Canine Teeth

The canine teeth are simple teeth. These teeth are the ones most likely to have large deposits of calculus (especially the lowers).

The Tooth

The horse has what is known as hypsodont dentition (high crowned teeth) with **peripheral crown cementum** (i.e. cementum on the outside of the crown of the tooth over the enamel). They have a reserve crown, which accommodates continual wear. As this reserve crown is within the alveolus, cementum covers the surface of the enamel to allow for attachment of the periodontal ligament.

The discolouration of horse teeth is due to food pigments staining the dead cementum of the crown. This is not calculus as seen on the teeth of small animals. They can, of course, get calculus deposits.

The tooth of the horse is composed of enamel, cementum and dentine as with other species. The development of the cheek teeth, however, is markedly different. During development, deep enamel infolding occurs forming enamel lakes (infundibulae). These lakes are filled with cementum, which receives its nutrition from blood vessels entering the enamel lake.

Eruption of the tooth disrupts this blood supply and the cementum dies. If the cementum in the infundibulum is incompletely formed at this time, a deficiency in calcification occurs. When the crown wears to the level of the softer cementum, food can accumulate in the defect and bacterial decay of the cementum may follow (previously called infundibular necrosis). This may eventually communicate with the pulp leading to endodontic involvement and eventual loss of the tooth.

Ageing

- Notes supplied courtesy of Assoc Prof Gary Wilson

Techniques used for ageing of the horse are based on the age-related changes to the dentition. To accurately age horses, the practitioner must understand these changes.

Every practitioner involved with horses should carry a copy of the American Association of Equine Practitioners' booklet entitled "Official Guide for Determining the Age of the Horse". This is an excellent booklet and can be used to "refresh" your memory or to illustrate to a disbelieving client why you disagree with the supposed age of the horse. Remember that, as well as your reputation often depending on the accurate ageing of the horse, the legal implications of a mistake can be costly.

A quote from the preface of the above text is worth repeating:

> "This text is based on the premise that teeth provide the most precise tool available for the determination of the age of a horse. Teeth appear, develop, wear, change form and are shed with a regularity that veterinarians have learned to recognise with high degree of accuracy.
>
> It must be recognised that art of age determination is not an exact science. There are many variables, which may result from conditions such as the nature and quality of feed, environmental factors, heredity and disease. Consequently, in making any age determination, the examiner must consider **all** points illustrated herein, as well as **all** clinical factors that may have affected the appearance of the teeth of the horse in question."

For age determination in the horse, the characteristics used are those of the incisors:

- the eruption times of each of the incisors
- the shape and appearance of the occlusal surface of the lower incisors
- the bite alignment of the incisor arcades
- the presence of hooks and grooves on the upper corner incisors

Deciduous Dentition

A rough guide used to approximately age foals and yearlings is as follows:

6 days - central incisors present

6 weeks - centrals and intermediates present

6 months - all incisors present (corners just erupted)

12 months - dental star present in centrals & corners not in wear (molar 1 present)

18 months - corners in wear

24 months - dental star in all lower incisors (molar 2 present)

Permanent Dentition

Initially, ageing using the permanent dentition involves only the eruption and "in-wear" times of the incisors:

2½ years	permanent central incisors erupted (but not in wear)
3 years	centrals in wear
3½ years	intermediates erupted (not in wear)
4 years	centrals & intermediates in wear
4½ years	corners erupted (not in wear)
5 years	all incisors in wear (the dentition is complete at this age)
6 years	corner incisors in full labial occlusal contact
7 years	lower corner incisors in full occlusal contact lingually

After this age, the accuracy of ageing by dentition decreases as it relies solely on the occlusal forces causing attrition.

As the tooth wears, the infundibulum becomes shallower and smaller and moves lingually (towards the tongue). With increased attrition, the pulp cavity risks becoming exposed. Initially, the odontoblastic processes in the dentinal tubules are stimulated and the odontoblasts seal the tubule with secondary dentine. With further attrition, layers of secondary dentine are produced to seal the pulp cavity from exposure.

Secondary dentine is dark brown in colour = dental star. This occurs labial to the infundibulum. The dental star, once present, will be visible until the tooth is lost. With time, a white spot will appear in the centre of the dental star (it is not known what this is).

After 7 years of age, the shape of the occlusal surface, presence or absence of hooks and grooves, angle of the bite plane as well as the loss of the infundibulum (cup) and appearance of the dental star are used to estimate the age. The older the horse, the more subjective ageing becomes (it pays to examine brands, etc., for some guidance). The following are approximate guides only:

7 years	cups disappearing from centrals (central enamel only), oval shaped occlusal surface
8years	cups present in corners only, central enamel nearer lingual border
9years	incisors oval; cups gone; dental star (appears as a light brown line labial to central enamel) in centrals
10 years	Galvayne's groove at gum margin of corners; centrals & intermediates round, corners oval; central enamel of centrals close to lingual border
10 - 15 yrs	dental tables of centrals change from round to triangular; central enamel closer to lingual border & then disappears

15 years	Galvayne's groove half way down corner; centrals triangular, corners round; bite plane starting to become more angled
18 years	all triangular; dental star round & in centre
20 years	Galvayne's groove extends full length of corner; "long in the tooth"
20 + yrs	Galvayne's groove moves down the corner until grown out

Age related changes

Teeth with reserve crown erupt due to hydrostatic pressure at the apex of the tooth (root end) and the complex process of periodontal fibre release and re-attachment. The hydrostatic pressure build-up is the result of vascular changes, which are associated with osteolysis around the root apex. This often results in eruption cysts along the ventral border of the mandible associated with the eruption of the permanent teeth (e.g. the "3 year old bumps"). These eruption cysts may be present in the maxilla as well. The eruption cysts can be regarded as a “normal abnormality”.

Impaction (often only temporarily) of the last cheek tooth to erupt (P4) leads to changes of the vasculature within the tooth. This can result in pulpitis and progression of the eruption cyst to a draining fistula. Bacterial contamination then occurs and the tooth is "doomed".

The eruption of the permanent dentition into the mouth results in the loss of the remnants of the deciduous teeth (dental caps). The roots of the deciduous teeth are resorbed by the odontoclasts as a consequence of the pressure of the erupting permanent teeth pushing from beneath. Hence, if the permanent tooth is not following the correct path, complete resorption of the subgingival components of the deciduous teeth will not occur and the "cap" will be retained (often in a displaced position). The permanent tooth will, therefore, not be in correct alignment with the rest of the arcade and rapid development of dental pathology occurs.

Studies by Kirkland and Baker (1996) show that, at eruption, there are no roots present and no definable pulp chamber. It takes a minimum of 3 years for maturation and separation of the root system.

These studies found that, in the first year after eruption, overall tooth length increased, as the rate of wear was less than the increase in root length. During the second year, tooth length was static and in subsequent years, net loss of tooth length occurred as the rate of attrition was greater than root lengthening. The rate of crown loss increased each year up to 5 years post-eruption then decreased (the rate of root formation was also highest up to 5 years post-eruption). This higher rate of wear in the first 5 years post-eruption causes a greater propensity for the formation of sharp enamel points. For this reason, horses up to 9 years of age require more frequent oral examination, as staggered eruption of the teeth occurs so these horses have teeth in the 5-year post-eruption period.

Reference

Kirkland, K.D., Baker, G.J., Maretta, S.M., Eurell, J.O.C. & Losonsky, J.M. (1996). Effects of aging on the endodontic system, reserve crown, and roots of equine mandibular cheek teeth. *Am. J. Vet. Res.* **57:** 31.

Dental Nomenclature

Noted supplied courtesy of Assoc Prof Gary Wilson

There are multiple ways to describe the surfaces of the teeth e.g.:

Buccal Lingual Palatal Labial

Mesial Distal Occlusal Incisal

There are also three methods of identifying the individual teeth:

(a) The anatomical system uses the correct anatomical name for the tooth e.g. upper right second premolar (URP2). The main advantage of this system is that everyone knows exactly which tooth is being discussed.

(b) The modified triadan system uses a different three digit number for each tooth. The first number identifies each quadrant of the jaw:

1=upper right

2=upper left

3=lower left

4=lower right

5=deciduous upper right

6=deciduous upper left

7=deciduous lower left

8=deciduous lower right

The teeth are then numbered from the midline at the front to the back e.g. 106. The advantage of this system is its supposed ease of use.

(c) The third system is the <u>cheek teeth system</u>. This is similar to the anatomical system except the cheek teeth (premolar 2 to molar 3) are numbered cheek teeth 1 to 6.

Hence a wolf tooth could be defined as:

(a) Upper right premolar 1 (URP1).
(b) 105
(c) Upper right wolf tooth

It does not matter which identification system you use but it must be used correctly (i.e. you must know which tooth is being discussed).

The system most universally used by "equine dentists" is the Modified Triadan System even though most of these horse dentists don't understand it! I personally prefer the anatomic system as it allows me to perceive the function of the tooth as well as its development.

The Modified Triadan System for Identifying Teeth

<u>Points of note:</u>

1. In January 1972, the International Dental Federation adopted the new 2 digit nomenclature system for use in humans. The 1st digit represents the quadrant of the mouth [e.g. 1 is the upper right, 2 the upper left, 3 the lower left and 4 the lower right – i.e. <u>*moving clockwise as you look at the patient*</u>]. The 2nd digit represents the location of the tooth counting from the midline toward the back of the mouth numbering from 1 to 8. Hence the same tooth in each quadrant has the same 2nd number.

2. The adult permanent dentition uses 1 to 4 as the 1st digit whereas the deciduous [or primary dentition] is designated as 5 to 8. Hence the deciduous upper right 2nd incisor would be 52 and the permanent would be 12.

3. The same year, Prof. Triadan [a human dentist from the University of Bern, Switzerland] introduced a similar system for animals using the canine model. As most animals have more than 9 teeth in an arcade, he used 3 digits instead of the 2 used for humans. As example, here an upper left permanent canine is a 204 [deciduous is 604], a permanent upper right 4th premolar is 208 and lower left 2nd molar is 310.

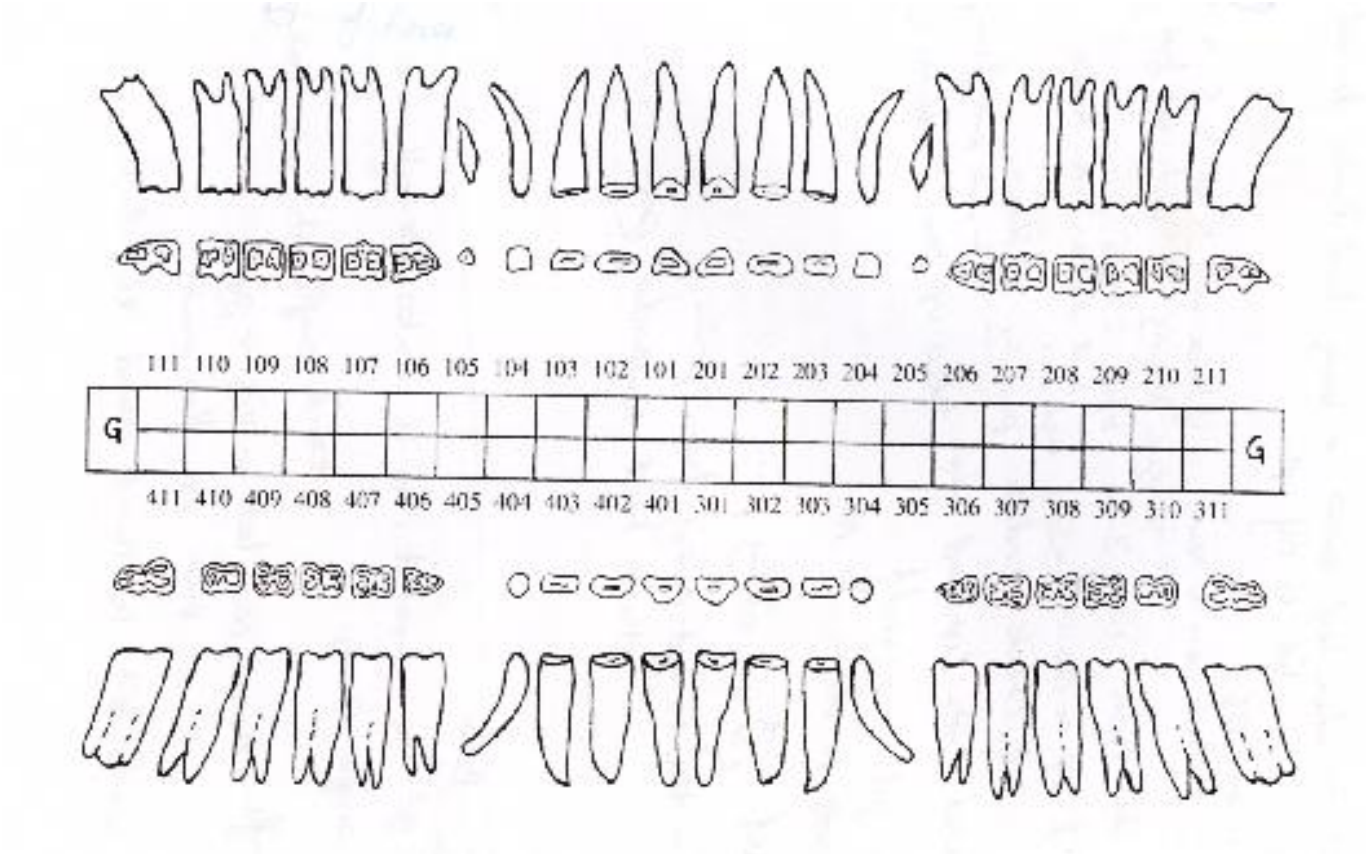
4. This system did have problems when different species were compared as the same tooth anatomically had different numbers in certain species. The cat, for example, with its missing premolars would have the upper right carnassial tooth designated as 107 [108 in the dog]. In 1990, Leigh West [later West-Hyde] described the feline dentition with the correct anatomical names for each tooth and suggested that the Triadan system should reflect this.

5. In 1991, Michael Floyd developed the Modified Triadan System. The basic concept in this is the "Rule of 4 and 9". All canine teeth end in 4 and all 1st molars end in 9. This system can be applied to all species. The 1st upper right cheek tooth of a horse would therefore be a 106 [permanent] or 506 [deciduous] irrespective of whether the horse had wolf teeth or canines present.

References:

Floyd, MR (1991) The Modified Triadan System: Nomenclature for Veterinary Dentistry. *J Vet Dent* **8**: 18.

West, L (1990) The Enigma of Feline Dentition. *J Vet Dent* **7**: 16.



Editor's note:

When working on a horse, to remember the triadan numbers relating to the actual tooth, look at the horse from the front, and remember to start at the upper right quadrant as the 100 quadrant. To advance to the 200, 300 and 400 quadrant, move clockwise when facing the horse.

Designate some teeth are marker pegs (even if they are missing)

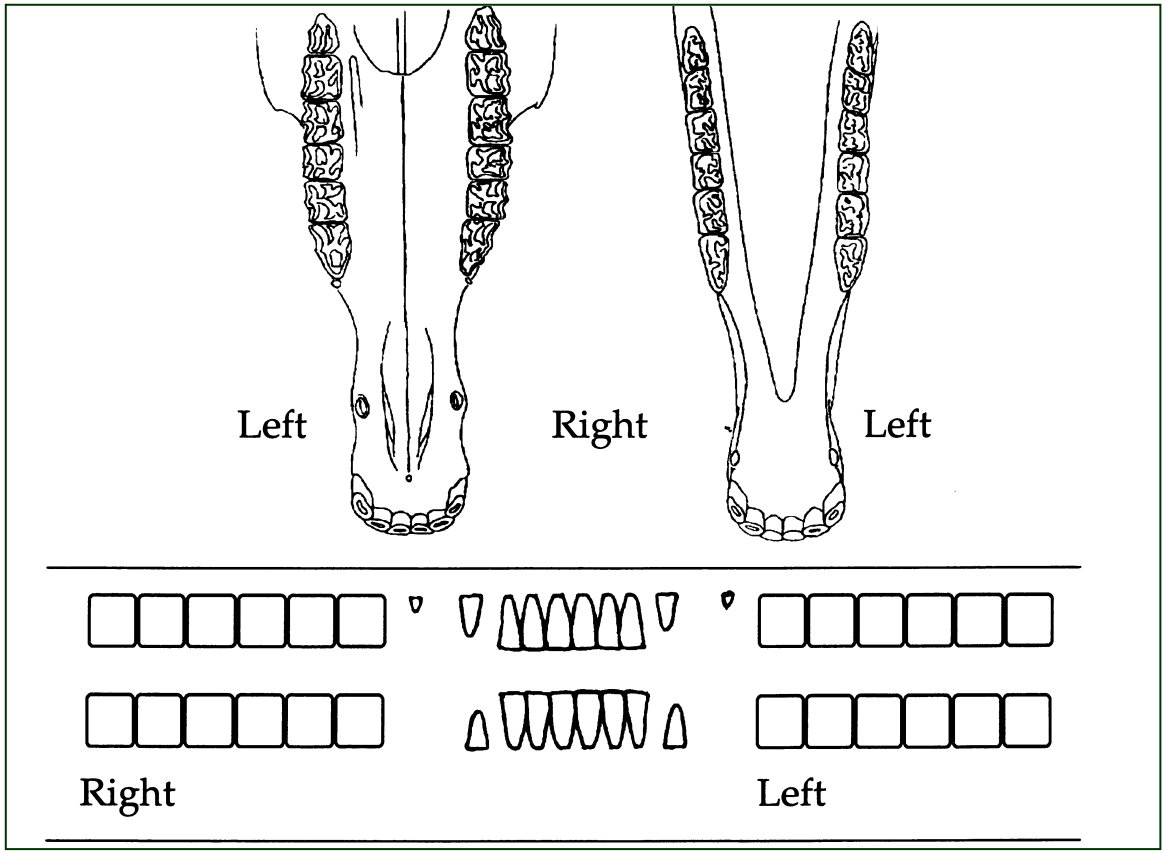
eg 01 is always going to be the central incisor

04 will always be a canine – present or not!

06 will always be the second premolar (first cheek tooth)

09 will always be the first molar.

11 will always be the last molar (M3)


Left
Right
Left
Right
Left