How to Perform an Oral Examination Utilizing a Five-Component Protocol

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1. Introduction
For years, the equine oral exam was a procedure in veterinary practice performed primarily to determine whether the horse's teeth were in need of "floating." As modern equine dentistry has advanced, our knowledge and understanding of equine oral health has greatly expanded, leading to a need for a more systematic and thorough examination approach. Protocols in other species utilize specific components related to the oral cavity and teeth in order to systematically perform the examination. Adapting similar principals to horses, the components of an oral examination include the following:

1. Extraoral examination of the head.
2. Evaluation of occlusion.
3. Evaluation of the periodontal tissues.
5. Evaluation of the oral soft tissues.

The purpose of this paper is to outline a five-component protocol for oral examination. It is beyond the scope of this manuscript to address detailed descriptions of oral pathologies and detailed dental charting procedures. Further reading can be found in well-written texts for abbreviations and information regarding recordkeeping of oral findings. Using a systematic approach to oral examination minimizes the risk of overlooking oral pathology and helps the veterinarian formulate an appropriate treatment plan for the patient.

2. Materials and Methods
A thorough history and physical examination of the patient should be performed prior to administering sedation for dental procedures. Instrumentation recommended for the oral examination includes a full mouth speculum, support for the head (headstand or dental halter), bright light source, oral dosing syringe, intraoral mirror, periodontal depth probe, and occlusal surface explorer. The author prepares an oral rinse solution for the instrument bucket by adding 10 ml to 20 ml of chlorhexidine gluconate (2% solution) per gallon of water. The presence of chlorhexidine solution in the rinse bucket also helps eliminate fogging of the dental mirror. Additional instrumentation that may aid the exam includes periodontal forceps, alligator forceps, and a dental scaler.

A dental chart is utilized to record findings. The chart utilized by the author (Fig. 1) has been designed to encompass all five components of the exam. The front page is used for recording pertinent oral findings for individual dental quadrants and the back page of the chart allows formulation of...
3. Results

Extraoral Examination
This component is usually performed prior to sedation and involves visual and tactile assessment of the head region. Performing the extraoral examination prior to sedation allows the practitioner to more accurately evaluate symmetry and whether the patient reacts painfully to palpation of different skull structures or abnormal areas of the head (this may be particularly important if attempting to rule-out jaw fracture prior to the mouth speculum being placed). Under normal conditions each of the ear pinnae, temporal muscles, temporomandibular joints, masseter muscles, orbits, globes, facial bones, and nostrils appear symmetrical in the horse. In some instances, if abnormalities of symmetry or abnormal swellings of the head are encountered, additional diagnostic testing may be indicated such as lab work, radiography, or computerized tomography.

Abnormal facial symmetry may result from the following conditions (Figs. 2A–2C):

Fig. 1. Equine dental chart used by the author’s practice. The front page is utilized for examination findings and back page for problem list, treatments, and complications/recommendations.
Abnormal swellings on the head may occur as a result of the following:

- tooth-root disease
- eruption cysts
- neoplasia
- sinus problems
- trauma
- guttural pouch enlargement
- lymph node enlargement
- salivary gland enlargement
- odontogenic cysts

Occlusion Examination

Evaluating Occlusion of the Incisor Teeth (Prior to Speculum Placement)

- When the horse’s mandible is in a centric position, normal occlusion between upper and lower incisors when viewed frontally is a level bite.
- When the profile of the incisor teeth is examined, the labial edge of the upper and lower incisors meet evenly in normal occlusion; however, this is somewhat dependent upon head position in that the mandible retracts when the poll is extended and protrudes when the poll is flexed.
- Lateral excursion can be assessed to document the extent of molar occlusion using the methods of Rucker.7

Evaluating Occlusion of the Cheek Teeth

- The horse’s anatomy results in a sloped chewing surface with enamel points on the buccal aspect of the upper cheek teeth and the lingual aspect of the lower cheek teeth.
- The mandible and maxilla have differing width (anisognathia), and the mandibular cheek teeth appear slightly more narrow than the maxillary cheek teeth.
- The rostral portion of the left and right upper rows of cheek teeth curve slightly toward midline.
- There is a normal upward curvature of the occlusal surface of the caudal aspect of the upper and lower dental quadrants (Curve of Spee).

Descriptions of Malocclusion

There are several descriptive terms for malocclusions in the horse. Malocclusions are often described when there are overlong portions of the
dentition involving the clinical crown due to a lack of attrition from opposing teeth. This situation is progressive and without intervention from the practitioner, can result in poor mastication, soft tissue injury, and overall poor health. It is important for one to identify why there is a lack of attrition as this is often the primary disease and the overlong portion of crown is a secondary response. Therefore, it is important to not only identify the overlong tooth/teeth but to identify the pathology causing the lack of attrition.

The nomenclature committee of the American Veterinary Dental College (AVDC) has divided malocclusions of dogs into two different types. They are described as skeletal malocclusions and dental malocclusions.8 Malocclusions can be described as skeletal malocclusions when they are related to an anatomical discrepancy of the jaws. Dental malocclusions are malocclusions that are related to positioning of individual teeth within normal jaws. Horses can have combinations of dental and skeletal malocclusions; an example would be an overbite in addition to a missing left mandibular first molar (Triadan 309) with an overlong left maxillary first molar (Triadan 209) representing a dental malocclusion. One must also have a working knowledge of equine dental anatomy pertaining to age and the eruption pattern of teeth as this will account for some malocclusions that can be noted in juvenile horses.9 The scope of this paper is not to discuss every potential malocclusion but to have the reader understand the difference of skeletal versus dental malocclusions. This will allow the practitioner to formulate a dental treatment plan. When evaluating occlusion and planning treatment, the author keeps the following concepts in mind:

Skeletal malocclusions are teeth in an abnormal position as a result of asymmetry or deviations that exist between the bones that support the teeth. Skeletal malocclusions are noted when there is maxillary-mandibular asymmetry, which can be seen in a rostro-caudal, side-to-side, or dorso-ventral direction. Examples of these types of malocclusions are what have previously been described as overbite, underbite, wry nose, and several other terms. Using overbite as an example, the horse has an abnormal conformation where the mandible occludes caudal to its normal position with the maxilla. This can cause malocclusions of the incisors, premolars, and molars. In general, skeletal malocclusions will have several teeth affected and be subject to ongoing occlusal adjustments to maintain the dental quadrants. Examples include mesial hooks, distal hook/ramps, excessive transverse ridges, and overlong maxillary and mandibular incisors that can be seen in horses with overbite or underbite.

Dental malocclusions are noted when specific teeth are out of normal position in the dental quadrant and the supporting bones have a normal relationship. Examples of a dental malocclusion would be an overlong supernumerary tooth lacking wear during mastication from an opposing tooth. This would result in a dental malocclusion. Other examples of dental malocclusions are situations where teeth are missing from a quadrant or where there is overcrowding and a tooth is not in a normal alignment with the rest of the teeth in the quadrant. When a malocclusion involves a tooth angled towards the tongue, the tooth is linguoverted. If the malocclusion involves a tooth angled towards the cheek, it is buccoverted. There are several other descriptive terms for teeth that the reader can find in the nomenclature section of the AVDC website (http://www.avdc.org/nomenclature.html#occlusion). Remember that a dental malocclusion is often related to a single tooth or a few teeth and can be secondary to other disease processes.

Classifications of Malocclusions

The nomenclature committee of the AVDC has further accepted a classification of symmetrical skeletal malocclusions which are described by the relationship of the mandible to the maxilla.8 This classification system has also been described for use in the horse.10

Neutroclussion (Class 1 malocclusion; MAL/1): a normal rostral-caudal relationship of the maxillary and mandibular dental arches with malposition of one or more individual teeth. This would be an example of a dental malocclusion without a skeletal malocclusion. An example would be a horse with normal rostro-caudal relationship with an overlong left maxillary M1 (Triadan 209) as a result of a missing left mandibular first molar (Triadan 309) (Fig. 3A).

Mandibular distoclusion (Class 2 malocclusion; MAL/2): An abnormal rostral-caudal relationship between the dental arches in which the mandibular arch occludes caudal to its normal position relative to the maxillary arch. This was formally described as relative maxillary prognathia or parrot mouth. Dental malocclusions would be listed separately (Fig. 3B).

Mandibular mesoclusion (Class 3 malocclusion; MAL/3): An abnormal rostral-caudal relationship between the dental arches in which the mandibular arch occludes rostral to its normal position relative to the maxillary arch. This was formally described as relative mandibular prognathia or monkey mouth. Dental malocclusions would be listed separately (Fig. 3C).

The author’s opinion is that identifying the type of malocclusion, whether skeletal or dental, brings greater understanding of how to address the overlong dentition. For instance, a skeletal malocclusion will never be fixed, but can be maintained through serial occlusal adjustments. Dental malocclusions, however, can be secondary to other pathology that the practitioner may need to treat along with correcting the malocclusion.
Oral Soft Tissue Examination

The oral soft tissues include the tongue, lips, cheek, mucosa, hard and soft palate, and interdental space. Examination of these structures may identify bleeding, abnormal growths, oral ulcerations (which are full thickness mucosal lesions; Fig. 4A), or abrasions (partial thickness lesions of the mucosa; Fig. 4B). The presence of mucosal lesions can often be associated with sharp enamel points or training hardware on the bars of the mandible and in the commissure of the lips. If an abnormal oral mass is identified, an incisional biopsy can be obtained at the time of the examination (Fig. 4C). Mucosal enlargement can be related to retained teeth, as in the case of retained maxillary first premolars (Triadan 05); if these are detected, radiographs should be obtained demonstrating the retained tooth. Lacerations also can be associated with any of the oral soft tissues, particularly the tongue, lips, hard palate and soft palate (Fig 4D). If an injury of the tongue is noted, a radiographic or ultrasound examination may be indicated to rule out a penetrating foreign body such as wire.

Examples of oral soft tissue problems are below:

- bleeding
- abnormal growths
- ulcerations
- abrasions
- lacerations

Important Note on Periodontal and Endodontic Examination

The periodontal tissues and endodontic structures of the clinical crowns of the incisor teeth and canine teeth are readily available for examination at the front of the mouth prior to speculum placement. An intraoral mirror or oral endoscope is utilized to better visualize the cheek teeth after opening the speculum. It is important to thoroughly rinse organic debris from the mouth so that the periodontal and endodontic components can be examined.

Periodontal Examination

Oral lesions associated with periodontal problems include the following:

- periodontal pocketing of roughage
- gingival enlargement
- gingivitis and bleeding
- pathologic diastemata
- gingival recession
- halitosis
- calculus accumulation

The structures relating to the periodontia are the gingiva, gingival sulcus, periodontal ligament, cementum of the tooth, and the alveolar bone. The normal depth of the gingival sulcus of the incisors, canine teeth, and cheek teeth in the horse is generally considered to be 3 mm to 5 mm.


disease is a progressive condition first recognized as gingivitis. If the alveolar bone becomes affected then the condition is termed periodontitis. The presence of periodontitis can only be determined by obtaining radiographs of the affected area and assessing the amount of bone loss*(Fig. 5A and 5B).*

Periodontal disease is often painful for patients and local anesthesia may be needed to complete the exam. Investigation of a periodontal problem includes removal of entrapped roughage using irrigation and instrumentation (i.e., alligator forceps and right angle perio forceps). The periodontal depth probe is utilized to explore the gingival sulcus and measure pocket depths. Tooth mobility is a function of periodontal attachment and, if compromised, an increase in tooth mobility will be noted*(Table 1).* The author places the tip of a dental scaler on the occlusal surface of a tooth and manipulates the instrument in order to assess the mobility of individual teeth. It is the author’s opinion that in all horses with a periodontal finding, radiographs should be obtained so that staging of the periodontal disease can be performed*(Fig. 5C).* Further information about evaluating periodontal tissues of the teeth can be found in another manuscript in this section.

Endodontic Examination

Structures to be examined include the occlusal aspect of the infundibula of the incisor teeth and maxillary cheek teeth, the occlusal surface of the pulp chambers of the incisor teeth, and pulp horns of the cheek teeth. Normal dentin associated with the occlusal aspect of the pulp has a characteristic tannish color, depending, in part, on pigmentation from forage. More information regarding dentin classification and characteristics of equine dentin is covered in a different manuscript in this section. Areas where food is adhering to the surface of the teeth should be rinsed clean and an occlusal surface explorer used to determine if pathology is present. An abnormality of dentin over the occlusal aspect of the pulp may be associated with deeper endodontic problems and it is important during this component of the examination to attempt detection of irregularities such as fractures, caries, or necrotic pulp exposure. Radiography can be performed to better assess teeth with endodontic problems and to evaluate surrounding bone and sinus structures. Small fissure lines through occlusal dentin and enamel are frequently identified in cheek teeth, but the significance of these subtle lesions is not understood. When an irregular surface is noted, the occlusal surface explorer should be used to investigate the structure*(Figs. 6A and 6B).* Abnormal or necrotic areas of dentin over the occlusal end of the pulp will usually appear dark in color and contain feed material. The tip of the explorer will ‘catch’ or bury into the abnormal dentin or pulp tissue.

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*Fig. 4. A, Mucosal ulcer associated with overlong crown of 206. B, Mucosal abrasion (arrow) from overlong 207. C, A mass on the lingual aspect of the 300 dental quadrant was identified as an oral mandibular fibrosarcoma. D, Example of a severe tongue laceration.*
Tooth fractures are considered an important finding of the endodontic exam. When a fractured tooth is encountered, attempt to use the tip of the explorer to investigate the fracture line. One must determine if the pulp horn or chamber has been exposed and is devoid of dentin or if dentin exists within the pulp chamber or horn. The presence of dentin indicates a barrier that could be protective vital pulp tissue, preventing bacterial and food migration to the apex of the tooth. Classification of the fracture is based on involvement of specific tooth structures and whether pulp involvement is noted (Table 2). Fractures above the gumline are considered crown fractures. A complicated crown fracture is a fracture of the clinical crown that involves the pulp horn or pulp chamber of the tooth, while an uncomplicated fracture does not involve the pulp. If the fracture incorporates the clinical crown and extends below the gumline, it is considered to involve the root of the tooth and is termed a crown root fracture (the horse has a reserve crown of tooth below the gumline which brings confusion to this classification; the reserve crown below the gumline in the horse has periodontal ligament attachment and functions similar to the root structure). Root fractures are fractures of the tooth only below the gumline and do not involve the clinical crown of the tooth.

An infundibulum is a blind invagination of enamel from the occlusal surface that is normally filled by cementum. Disorders of the infundibula of maxillary cheek teeth include incomplete cemental filling, which is thought to predispose to carious decay. Infundibular caries are frequently noted in the infundibula of the maxillary cheek teeth and must be differentiated from areas of abnormal dentin over a pulp horn by the examiner. Infundibular caries are classified according to stage of their progression (Fig. 6C); advanced infundibular disease may lead to development of fractures and periapical infection.

### Table 1. Tooth Mobility Scores

<table>
<thead>
<tr>
<th>Mobility Score</th>
<th>Amount of tooth movement</th>
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<tbody>
<tr>
<td>0</td>
<td>Normal tooth and periodontium</td>
</tr>
<tr>
<td>1</td>
<td>First discernible sign of tooth movement</td>
</tr>
<tr>
<td>2</td>
<td>&lt;3 mm tooth movement</td>
</tr>
<tr>
<td>3</td>
<td>&gt;3 mm tooth movement; the tooth can be depressed into alveolus</td>
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4. Discussion

An oral examination that follows this approach results in the practitioner evaluating specific areas related to the oral cavity and facilitates association of lesions with specific disease entities (e.g., a valve diastema is a component of periodontal disease). The component-based exam essentially gives the
practitioner a checklist to follow and decreases the temptation of identifying and focusing on a lesion without completing the entire examination, potentially missing other pertinent pathology. Studies have shown that equine dental disease can be present in 36% to 85% horses in first opinion practice. It is the author’s experience that many horses presenting for “routine” dentistry with no history of oral problems will have findings noted after thorough examination where further treatment and diagnostics are indicated.

5. Summary

The oral examination should result in a complete assessment of the patient’s oral health and using a five-component protocol helps bring greater understanding to the veterinarian of oral lesions as they pertain to specific dental disease categories. Adhering to a systematic approach should improve the veterinarian’s likelihood of identifying and managing equine oral pathologies prior to becoming advanced problems.

Acknowledgments

Conflict of Interest

The Author declares no conflicts of interest.

References


Table 2. Tooth Fracture Classification

<table>
<thead>
<tr>
<th>Tooth fracture classification</th>
<th>Description</th>
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<tbody>
<tr>
<td>Complicated fracture</td>
<td>Involves pulp</td>
</tr>
<tr>
<td>Crown fracture</td>
<td>Fracture of clinical crown that does not extend below gum line</td>
</tr>
<tr>
<td>Crown-root fracture</td>
<td>Fracture incorporates the clinical crown and extends below the gum line</td>
</tr>
<tr>
<td>Root fracture</td>
<td>Fracture of the tooth below the gum line not involving the clinical crown</td>
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Fig. 6. A. Occlusal surface explorer is used to confirm the presence of exposed pulp horn #1 Triadan 106. B, Exposed pulp horns #1, 3, 6 of Triadan 206. Discoloration and trapping of roughage in the affected pulp horns is visible with close inspection. C, Infundibular caries staging system used by the author (adapted from Dacre): Stage 0—Normal tooth; Stage 1—Caries involve cementum only; Stage 2—Caries involve cementum and infundibular enamel; Stage 3—Caries involve cementum, infundibular enamel, and surrounding dentin; Stage 4—Fracture of the tooth has occurred, extraction may be indicated; and Stage 5—Tooth has fractured such that it is nonvital and extraction is indicated.


How to Incorporate Oral Endoscopy Into an Equine Dental Examination

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1. Introduction

Accurate identification and documentation of pathology is very important for dental treatment planning. The interdental space, canine teeth, incisor teeth, and associated gingival tissues are positioned near the opening of the mouth and do not require sophisticated techniques for detailed examination and documentation. However, challenges exist in achieving adequate visualization of the caudal portion of the oral cavity due to a number of factors including the following:

- Relatively small mouth opening compared to the length of the oral cavity.
- Presence of a large, powerful tongue that obstructs visualization and impedes instrumentation.
- Restricted buccal space with tight adherence of the cheeks and skin to the skull.

Intraoral imaging systems can be utilized by veterinarians to augment dental examination and to provide intra-operative guidance during extraction or dental treatment procedures. The magnified image generated by an intraoral imaging system greatly improves visualization and allows detailed examination (Fig. 1). Generally speaking, instrumentation for intraoral imaging is classified as follows:

- **Oral endoscopic system**: consists of a rigid endoscope, light source, digital video camera, video monitor, and recording device. Rigid endoscopes for equine use typically have a diameter of 5 mm to 15 mm, working length of 50 cm, and an angled viewing lens of 60 to 115°.
- **Handheld intraoral camera**: adapted from human dentistry, these have a short, self-contained handpiece (approximately 22 cm long) coupled via USB to a computer with a monitor and software for viewing and recording. The device contains a built-in fixed focus camera with an LED light source and an image capture button located on the handle.

The purpose of this manuscript is to describe the author’s approach using oral endoscopy as a component of dental examination and treatment. For a more comprehensive discussion on intraoral imaging systems and oral photography, the reader is referred to the manuscript by Galloway and Easley.
2. Materials and Methods

Endoscopic instrumentation (Fig. 2):

- Rigid endoscope (5.5 mm, 60°; working length 49.5 cm)\(^a\)
- Protective sheath (7.9 mm, 5.8 mm capacity, working length 45.7 cm)\(^b\)
- Video camera\(^c\) and video camera control unit\(^d\)
- Digital image capture device\(^e\)
- Video monitor,\(^f\) light source,\(^g\) light cable,\(^h\) and laparoscopy tower\(^i\)

Oral examination procedure sequence:

- Discuss the primary complaint and clinical history with the client.
- Enter the patient information into the image capture device to create a folder for photographs and video obtained during the endoscopic examination.
- Perform an appropriate physical examination and external examination of the head.
- Administer sufficient sedation and analgesia to minimize chewing motion, tongue movement, and head movements (e.g., detomidine hydrochloride\(^j\) 0.010–0.020 mg/kg IV with butorphanol tartrate\(^k\) 0.005–0.010 mg/kg IV).
- Rinse the horse’s mouth.
- Support the horse’s head in a comfortable position for the horse.
- Perform initial oral examination of the incisor teeth, canine teeth, interdental space, associated soft tissues, and gingiva.
- Insert and open the dental speculum, lower the head and rinse any roughage, food, or foamy saliva accumulated on the occlusal surface of the cheek teeth to improve visualization.
- Elevate the head to continue the intraoral examination utilizing a bright light source and traditional methods.
- After initial intraoral examination, move on to the endoscopic exam.

Intraoral endoscopic examination:\(^2,5,6,7\)

- Position the instrumentation tower and monitor for comfortable viewing by the examiner (Fig. 3).

Fig. 1. Examples of a handheld intraoral camera (left; photograph courtesy of Travis Henry, DVM; Elkhorn WI) and a rigid endoscope for equine oral examination (right).

Fig. 2. Components for intraoral endoscopy include a portable laparoscopic tower, video monitor, digital image capture device, video camera control unit, light source, video camera, and rigid endoscope (top). The video camera uncoupled from the endoscope (bottom).
- Dip the oral end of the endoscope in warm water to eliminate fogging (repeat as needed throughout the examination).
- Ideally, assistants retract the ipsilateral cheek and gently stabilize the tongue to the side opposite. This improves visualization and minimizes unwanted movement of the scope.
- At any point during the examination, abnormalities of the clinical crowns or gingiva can be investigated under endoscopic guidance.
- During the course of the examination, photographic images and video can be shot using the capture device controls (the tower should be positioned to allow one assistant to use the capture device controls).
- The examiner places a hand on the lower bite plate of the dental speculum (generally, the author’s right hand) to stabilize and guide the endoscope. The other hand is used to insert or withdraw the endoscope, rotate the instrument to the desired view, and adjust the focus ring and camera.
- Beginning on the right side of the horse’s mouth, position the endoscope between the upper and lower dental quadrants and focus to view the occlusal surface of 106.
- Carefully advance the scope to the distal aspect of the last upper cheek tooth, viewing the magnified image of the occlusal surface, gingiva, and interproximal space of each tooth.
- At the distal aspect of 111, the endoscope can be rotated slightly to view in a vestibular (buccal) direction and positioned toward midline; the scope is slowly withdrawn to examine the cheek and palatal aspect of the 100 quadrant (gingiva, teeth, and interproximal spaces).
- To examine the vestibular (buccal) aspect of the dental quadrant, the scope is reinserted to the distal aspect of 111 and positioned to view in a palatal direction from the vestibule. The endoscope is slowly withdrawn to examine the gingiva, teeth, and interproximal spaces.
- After completing the examination of the 100 dental quadrant, the endoscope is rotated to view the 400 quadrant and the examination is carried out in a similar manner.
- For mandibular teeth, gently pressing the tongue away from the teeth with a long retractor improves visualization by the endoscope.
- After the 400 quadrant, the endoscope is moved to the left side of the mouth to evaluate the 200 and 300 dental quadrants in a similar fashion.
- For visual guidance with intraoral procedures (e.g., verifying correct placement of a molar spreader), an assistant holds the endoscope with the desired view while the veterinarian has both hands free to position or manipulate instruments.

Fig. 3. Performing intraoral endoscopic examination.

Fig. 4. Occlusal surface of fractured tooth 309 (arrow); the tongue is pressed gently with a long retractor to improve visualization (left). The endoscope has been rotated to view the lingual aspect of 309 (right).
During the examination, an efficient method is to call-out the findings while an assistant records the information in the patient record.

At the completion of the procedures, images on the capture device are copied to a flash drive and labeled with appropriate descriptions.

Video and images are then copied from the flash drive to a storage drive on the local network.

Between patients, remove the camera and disassemble the protective sheath from the endoscope, wipe the instruments with isopropyl alcohol 70%, and flush the chamber of the protective sheath with alcohol solution.

3. Results

It is important to know that excessive tongue motion, and especially chewing motion, create difficulty focusing and stabilizing the rigid endoscope. Intravenous administration of detomidine hydrochloride and butorphanol tartrate works well, in the author's experience, to provide excellent sedation-analgesia and reduce chewing motion for oral examination and intraoral endoscopy. Having assistants available to gently stabilize the head and tongue and retract the ipsilateral cheek improves the steadiness of the endoscope. Using a long straight retractor to move the tongue away slightly from the mandibular teeth improves visualization; however, use of a tongue retractor sometimes incites excessive chewing action and requires heavier sedation in some horses.

Rigid oral endoscopy augments commonly used examination techniques and provides a detailed, magnified viewing of dental and soft tissue structures in the mouth. The improvement in visualization increases diagnostic confidence when confirming findings from the initial examination and the instrumentation facilitates the precise investigation and documentation of questionable or pathologic areas. The author finds that it can be more challenging to obtain the desired view of the vestibular (buccal) aspect of the upper cheek teeth compared to the other views, presumably due to the space restriction within the vestibule of the cheek. Oral endoscopy should not be viewed as a replacement for more commonly utilized examination procedures, but with it there is improved capability of detecting subtle changes that may be more difficult to visualize with a dental mirror, such as focal gingival recession or other lesions involving teeth located in the caudal portion of the mouth. Examples of oral conditions identified with endoscopy (Figs. 4–7) may include the following:

- Abrasions of the cheek and tongue
- Sharp enamel points
- Dental elongations
- Fissure lines involving dentin and enamel

Fig. 5. Large abrasion on the side of tongue (arrow) associated with sharp enamel points of 300 dental quadrant.

Fig. 6. A fissure is visible in the dentin associated with pulp horn #1 (PH#1) of a mandibular tooth (arrow).

Fig. 7. Necrotic pulp exposure of pulp horn #5 (PH#5) is confirmed and documented under endoscopic visualization.
Diastemata
Periodontal pockets
Gingival recession
Necrotic pulp exposure
Crown fracture
Infundibular changes
Peripheral cemental abnormalities
Supragingival calculus
Parasitic larvae (*Gasterophilus* sp.)

In addition to oral examination, using the endoscope improves visualization and accuracy for other dental procedures (Fig. 8):

- Investigating periodontal and endodontic abnormalities involving the clinical crown.
- Positioning the molar spreader.⁷
- Positioning dental forceps and right-angle dental picks.⁴
- Positioning a drill bit.
- Intraoral guidance of extractions when utilizing minimally-invasive buccotomy instrumentation.
- Placing an alveolar packing.
- Inspecting the dental alveolus intra-operatively and post-operatively.

4. Discussion

Intraoral examination with rigid endoscopy appears to be safe and effective as previously reported by others. With the procedure, there is significant enhancement of visualization that allows detailed examination of the vestibular (buccal), occlusal, lingual, and palatal aspects of the cheek teeth quadrants. The result is an improvement in diagnostic confidence, but it is important to remember when viewing the magnified images not to over-interpret subtle findings or unresearched types of pathology (e.g., dentin fissures). For the author, endoscopy is an important teaching tool and an extremely valuable component of examination when working-up cases of suspected dental disease. The video monitor allows an owner, trainer, students, or consulting colleagues to view the real-time images. An added benefit is that video or photographs archived from the examination can be reviewed at a later time, including follow-up evaluations and discussions with other veterinarians.⁵ When used for intraoral guidance, magnified viewing assists in the accurate placement of instruments during extractions and other procedures.⁴,⁷

The author’s preferred examination technique with the endoscope is similar to previous reports. The technique is easier to perform with two assistants retracting soft tissues and stabilizing the head, but the examination can be carried out quite successfully with less support. Keep in mind that the initial investment for a system can be very expensive and most of the components described in the manuscript are not well-suited for ambulatory endoscopy. There are manufacturers with compact rigid endoscopic systems that utilize a battery operated LED light source, USB camera, laptop computer monitor, and wireless transmission technology to improve portability. Alternatively, less expensive handheld intraoral camera systems can provide excellent intraoral viewing and allow more flexibility for in-house or ambulatory cases. Among a host of factors, the veterinarian should always investigate the instrument’s water-resistance specifications when considering purchase. Furthermore, it is advised to develop relationships with reputable manufacturers and to consult a trusted colleague familiar with the ins-and-outs of specific system components prior to purchase.⁷

Acknowledgments

Conflict of Interest

The Author declares no conflicts of interest.
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aRigid endoscope, Richard WOLF GmbH, Knittlingen, Germany.
bProtective sheath, Richard WOLF GmbH, Knittlingen, Germany.
cVeterinary Video Camera III, Karl Storz & Co., Tuttlingen, Germany.
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eStryker SDC3 image capture, 100–240V, 50/60 Hz, Stryker Endoscopy, San Jose, CA 95138.
fDell Corporation 21 in. monitor, Plano, TX 75075.
gStryker X8000 light source, 300 W, 100–240 V, 50–60 Hz, Stryker Endoscopy, San Jose, CA 95138.
hFiber optic cable 809590, Richard Wolf Medical Instruments Co., Vernon Hills, IL 60061.
iStandard video cart, Stryker Endoscopy, San Jose, CA 95138.
jDormesan, Zoetis, Florham Park, NJ 07932.
kDolorex, Intervet/Merk Animal Health, Whitehouse Station, NJ 08889.
How to Assess the Periodontal and Endodontic Structures of Equine Teeth

Jennifer E. Rawlinson, DVM, DAVDC

1. Introduction

The health of equine periodontal and endodontic structures is critical to evaluating the overall health of an equine tooth. The equine periodontium, comprised of the gingiva, alveolar bone, periodontal ligament, and cementum, is directly responsible for stabilizing and holding the tooth in place within the oral cavity. Periodontal disease is the inflammation and infection of the periodontium, and if left untreated, it can lead to extensive attachment loss of the tooth from surrounding hard and soft tissue structures. Mobility may even result if the attachment loss is greater than 25% to 50% of the remaining reserve crown and root. The equine endodontic system or endodontium is located within the root canals, common pulp chamber(s), and pulp horns of the teeth, and it is comprised of blood vessels, nerves, lymphatic structures, and connective tissue commonly referred to as dental pulp. The endodontic system is responsible for nourishing the majority of the cellular components that make up the main structure of the tooth via the dentin-pulp complex. Odontoblasts make up a significant portion of the dentin-pulp complex, and odontoblasts are responsible for creating and sustaining dentin. The continual generation of secondary and tertiary dentin by the odontoblasts is what protects the endodontium from exposure during the constant slow loss of dental structure during normal mastication.

Endodontic disease is inflammation and/or infection of the endodontium that may or may not result in pulpal injury, necrosis, and/or death. If the endodontium of a tooth is severely injured, the pulp will become necrotic and die. Without the pulp, the tooth is no longer able to develop or respond to normal attrition and abrasion (wear of the tooth from occlusal contact and feed material). If the initial injury did not already result in exposure of a pulp horn to the oral environment, then over time the normal continual wear of equine teeth will eventually expose the pulp due to non-responsive odontoblasts. Once nonvital pulp horns are exposed to the oral cavity, feed packing and bacterial invasion into the endodontic space commences. The nonvital tooth harbors infection that slowly percolates into the surrounding bone via the apical portion of the roots and channels within dead dental structures. It is important to note that endodontically nonvital teeth can still have a vital, intact periodontium due to the fact the periodontium receives nourishment from surrounding vasculature.
Disease of equine periodontal and endodontic tissue is well-documented in the literature. The most commonly identified abnormality of incisors particularly in young horses (<2 years of age) was transverse fracture with or without fracture of the surrounding bone and/or pulp exposure. The incisor pulp horn is particularly vulnerable to exposure because of its position on the labial aspect of the tooth. Incisor primary periodontal disease and periodontal disease in relation to equine odontoclastic tooth resorption and hypercementosis is well-recognized. Dental fracture, pulp exposure, apical infection, primary periodontal disease, and diastemata of cheek teeth have extensive reporting in the literature. Prevalence of equine periodontal disease has been reported to be as high as 75% in some regions, and 49.9% of horses in the general population have some level of disease. Fractures commonly occur in cheek teeth especially on the maxillary teeth. Endodontic disease can result from these fractures. Some additional causes of endodontic disease are excessive/rapid dental wear, severe infundibular carious lesions, severe periodontal disease, anachoreisis, dental malformation, iatrogenic damage, regional fracture/past trauma, and unknown. In order to fully assess the health of the periodontium and the endodontium of equine teeth, a thorough physical and oral examination needs to be performed. If there is any suspicion that these disease processes are present, a radiographic evaluation should be performed of the suspect region.

2. Materials and Methods

Necessary Instrumentation

- Sedation
- Medical grade BRIGHT headlight (a camping style headlight will not provide adequate light to see subtle lesions)
- Full mouth speculum
- Oral irrigation preferably under pressure
- Periodontal probe—thin (1 mm width) with mm demarcations up to 2 to 3 cm in length (the tip of periodontal probes should be BLUNT not pointed to avoid gingival injury)
- Explorer number 23 on equine handle
- Dental mirror with defogger (alcohol, warm water, light layer soap, commercial defogger, etc.)
- Dental scalers, curettes, and picks
- Cheek retractor
- Rigid oral endoscope (if available)
- Extraoral radiographic equipment
- Intraoral radiographic equipment (if available)

Pre-Oral Examination

It is important to gather a thorough patient clinical history and perform a complete physical examination. Owners can provide ample information regarding onset of clinical signs, feeding behavior, progression of condition, systemic health, performance, and response to past therapies, all of which could be significant in the determination of pathology presence, diagnostics, treatment planning, and prioritization of the dental condition relative to the overall status of the patient. Observation of mastication pre-sedation can also enhance the clinician's ability to assess oral function and watch for signs of discomfort.

Sedated Oral Examination

A previous session in this series reported on how to perform a complete oral examination in the horse. This portion will focus solely on how to assess the endodontic and periodontal health of a tooth. Evaluation of the endodontic and periodontal health of a tooth should ALWAYS be part of a complete oral examination.

The maxillofacial region of the horse should be examined as part of a complete oral exam. If endodontic or periodontal health is compromised, extraoral examination findings might include enlarged regional lymph nodes, asymmetry of the muscles of mastication, bony or soft tissue swellings, regions of buccal feed packing, fistula formation, regions of sensitivity, and nasal discharge. Once the extraoral portion of the examination is complete, the incisor and bar region of the oral cavity is examined followed by speculum placement and examination of the oral cavity proper and cheek teeth. The following lists specific steps to performing a thorough examination of the periodontal and endodontic structures within the oral cavity. This comprises only a portion of a complete oral examination.

1. Water irrigation and dental scalers, curettes, and picks are used to completely remove debris, packed feed, and calculus from the oral environment and dental structures.
2. When inspecting intraoral periodontal and endodontic structures, ALL aspects of the tooth and surrounding structures must be examined. This includes the labial/buccal, palatal/lingual, mesial, distal, and occlusal aspects. Inspection of these structures in the rostral portion of the mouth can be performed by proper hand placement and digital manipulation of tissues. An incisor speculum is only necessary when an area of interest needs prolonged and careful inspection. A full-mouth speculum is necessary for examination of the premolar and molar teeth. The use of a dental mirror is absolutely necessary to be able to adequately examine all soft and hard tissue structures especially in the caudal portion of the oral cavity. Oral endoscopy, if available, provides even better visualization of all intraoral structures, and its use is becoming more common among practitioners with dental expertise. Palpation can assist the clinician in finding some pathology and it is encouraged, but palpation alone cannot
identify subtle pathology or minor defects between teeth.
3. With the lip and/or cheek retracted from the dental structures, the alveolar mucosa, mucogingival junction, and gingiva, are inspected for signs of inflammation, irregularities, fistulation, and underlying swellings. Palpation can be useful in detecting changes in juga definition or underlying bone; the juga is the bony contouring over the region of the reserve crown and root most distinct in equid incisors. Asymmetry or age inappropriate juga definition can be a sign of underlying pathology.
4. The relative height of surrounding bone at the clinical crown-reserve crown or clinical crown-root junction is examined. The height of the bone encasing the teeth on the mandible and maxilla is referred to as the alveolar ridge. Signs of potential attachment loss (loss of the structures of the periodontium) and decrease in alveolar ridge height include gingival recession, abnormal discoloration of gingiva, severe gingival inflammation, feed packing around or between teeth, subgingival calculus, decrease in height of the dental papillae (interproximal gingival tissue), malpositioning of teeth, increased space between teeth, age inappropriate incisive angle, bleeding from around the tooth after irrigation and debridement, and dental mobility.
5. Regions of abnormal gingival contour, gingival recession, gingival inflammation, decreased alveolar ridge height, feed packing, subgingival calculus, and overall suspect periodontal structure should be investigated with the periodontal probe. The periodontal probe is used to measure attachment loss of periodontal structure from the reserve crown and root. The periodontal probe is slid gently along the outer aspect of the tooth running parallel to the angle of the tooth in the region of the gingival sulcus and possible defect. The normal gingival sulcus depth has been reported to be 1 to 5 mm in the horse. If the probe measures greater than 5 mm, an area of attachment loss has been identified, and if it runs along the dental structure, it is referred to as a periodontal pocket. Measurements of gingival sulcus depth in otherwise healthy looking tissue is not routine in the equid due to potential gingival sulcus trauma that may be caused by the probe in a moving patient.
6. After inspection of all the supporting structures of the tooth, the tooth itself is examined. Dental structure is examined from the periphery to the most central visible occlusal aspect of the structure. The condition of the peripheral cementum, enamel infolding, primary dentin, secondary dentin (overlying the pulp), infundibulum, and infundibular cementum are all examined closely for any signs of defect or loss. Knowing the normal structure and appearance of the clinical crown for all teeth at any age is critical to the ability to identify dental pathology.
7. The dental explorer is used to examine dentin for defects indicating pulp exposure and any portion of the hard dental structure that is in question. The tip of the dental explorer is sharply pointed in order to identify subtle defects. The tip of the explorer is properly used at a 90 degree angle to dental hard tissue, and the tip should never contact soft tissue. Using the explorer at a different angulation will decrease the sensitivity of the instrument.
8. If periodontal lesions or clinical crown defects involving the endodontium are identified, extraoral and intraoral (if available) radiographs are necessary to continue evaluation of the tooth and surrounding anatomy. Acquisition and interpretation of these radiographs has been well-described. In cases where endodontic disease is suspected but no intraoral pathology identified, radiographs are critical to the evaluation of the health of the tooth. Computed tomography may even be necessary if both radiographs and oral examination do not reveal conclusive evidence of tooth health or disease.

3. Results

The use of adequate lightening, oral irrigation, a full-mouth speculum, dental mirror, periodontal probe, dental explorer, cheek retractor, and radiography are considered basic equipment for the adequate evaluation of periodontal and endodontic structures within the oral cavity. Radiographs are critical to evaluating dental structures for periodontal and endodontic health. These facts are well known and published in a vast array of textbooks, review articles, and research articles within and outside of the equine world.

4. Discussion

Periodontal and endodontic disease can affect teeth either independently or together. Depending on the age of the tooth and the extent of pathology, one disease can lead to the other. Severe periodontal disease extending to the tooth root and apex can lead to infection of the pulp, and endodontic disease that results in regional tissue destruction can cause extensive loss of the periodontium. These are called perio-endo and endo-perio lesions, respectively. Usually disease of this extent warrants the extraction of the tooth.

Explorers are commonly referred to inappropriately as picks in the equine literature. Explorers are meant to extend and enhance digital tactile sensitivity of the user. In order to perform this function, the explorer needs to be very thin and small. The number 23 sheppard’s crook explorer has
proven to be rugged enough to withstand the motion of the equine oral cavity but sensitive enough to reveal small lesions. These explorers have been used in human and small animal dentistry for decades. Heavier equine dental picks cannot reveal small lesions like pulp exposures but they are useful for removing debris from and around dental structures. Dental explorers will catch or sink into regions of abnormal dental hard tissue. A dental explorer tip should slide smoothly over enamel and dentin, and cementum will feel either slightly roughened or smooth. Explorer tips that sink into softened dental hard tissue and defects indicate underlying potential pathology.

Evaluating dentin for changes in color and consistency will help determine the health of the endodontic system. Primary dentin, the dentin present within the tooth upon initial eruption, is highly mineralized and is roughly an off-white, eggshell color with a moderate degree of translucency. Secondary dentin, the dentin produced slowly by the odontoblasts on the periphery of the pulp horn over the lifetime of the tooth, is less mineralized and more prone to staining. Therefore, secondary dentin can range in color from a light tan to a dark brown in color depending on the horse’s forage. It is the secondary dentin that prevents pulp exposure over time due to normal attrition. A variation in secondary dentin coloration is considered normal. When regions of secondary dentin on the occlusal surface of the tooth lack shine, appear dull, or are deeply pigmented, a dental explorer should be used to examine the site closely for a defect. Secondary dentin should not stain black, and if a black, dull discoloration is identified with or without feed packing in the region of a pulp horn, then the health of the tooth is questionable and warrants further examination.

The use of the above technique and instrumentation for evaluation of the periodontal and endodontic structures of the teeth during oral examination is critical for recognizing and properly diagnosing disease of the structures. Although the tools and technique may require a minor investment of money and time, the reward of being able to repeatedly identify mild to severe pathology is beneficial to the horse and owner. The identification of pathology earlier in the course of disease allows for treatment and possible cessation of disease progression. The ability to visualize subtle dental defects creates a more direct path to appropriate diagnosis and treatment. Horse, owner, and veterinarian will benefit from the use of improved techniques for oral and dental assessment.

Acknowledgments

Conflict of Interest

The Author declares no conflicts of interest.

References

How to Document an Equine Oral Examination Using a Dental Chart

Lynn A. Caldwell, DVM

1. Introduction
Equine dental charts are an important component of adequate legally required record keeping. A dental chart allows detailed documentation and assists the practitioner with performing a consistent and methodical exam. Charting is the process of recording the state of health or disease of the teeth and oral cavity. It is an integral part of diagnosis, treatment planning, and monitoring. Small animal dental charts allow for notation of diagnoses, pathology, and procedures performed in each quadrant on each side of each individual tooth. The use of similar charting methods during detailed equine dental examinations and treatment allows for accurate annotation of the comprehensive oral health assessment and treatment of your equine patient and ensures accurate communication with colleagues who may follow-up or to whom the case may be referred. For a comprehensive description of equine dental charting, the reader is referred to the previously published manuscript by Galloway. The purpose of this manuscript is to demonstrate the author's preferred method of charting examination findings in equine dental patients.

2. Materials and Methods
Information about performing a detailed oral examination is covered by a different manuscript in this section. When filling out a dental chart standardized abbreviations and terminology are employed which make the process much more efficient than writing out exam findings in longhand. To this end, knowledge of appropriate dental nomenclature and abbreviations is necessary.

The Modified Triadan numbering system is the preferred system in veterinary medicine for annotating the specific teeth in the dental quadrants and has been in existence for quite some time in human and veterinary dentistry. In addition to Triadan nomenclature, the Academy of Veterinary Dentistry (AVD) has a Dental Abbreviation Code List including an Equine Dental Abbreviation List that can be found on the AVD website (http://www.avdonline.org). The abbreviation list includes codes for diagnostic problems and treatment procedures that pertain to soft tissue, incisors, canine teeth, and cheek teeth. These abbreviations are intuitive and keep the chart from becoming cluttered. A list that includes AVD equine dental abbreviations is provided in Table 1.

To chart examination findings, a straightforward simple method is to record the Triadan tooth number followed by the appropriate diagnostic abbreviation (Triadan number may follow the diagnostic abbreviation, depending upon the practitioner’s preference, with consistency being the most impor-
**Table 1. Diagnostic Abbreviations**

**Incisors:**
- **CV** Ventral curvature: upper central incisors extend beyond the level of the upper intermediate and corner incisors, "smile."
- **CD** Dorsal curvature: lower central incisors extend beyond the level of the lower intermediate and corner incisors, "frown."
- **DGL** Diagonal: lower incisors longer on either the left side or right side. Defined with respect to mandibular incisors longer on arcade number 300 or 400. DGL/4 (400 arcade longer), DGL/3 (300 arcade longer)
- **MAL2** Class II malocclusion, overbite, brachygnathism, mandibular brachygnathism: extension of upper teeth vertically beyond lower teeth. Defined by the term “distoclusion,” where some or all of the mandibular teeth are distal in relationship to their maxillary counterparts.
- **MAL3** Class III malocclusion, underbite, prognathism, mandibular prognathism: defined by the term “mesioclusion,” where some or all of the mandibular teeth are mesial in their relationship to their maxillary counterparts.

**Cheek Teeth:**
- **HK** Hook: excess crown longer than wide.
- **RMP** Ramp: excess tooth wider than long.
- **WV** Wave: more than one tooth with excess crown.
- **STP** Step: one tooth only with excess crown.
- **ETR** Excessive transverse ridges: ridges in excess of 3 mm in height.
- **PTS** Sharp enamel points: buccal cusps on maxillary cheek teeth and lingual cusps on mandibular cheek teeth sharpened from wear (attrition).
- **CUPD** Cupped: crown worn past infundibulum. Still has crown above gingival margin. Can also be seen in lower teeth.
- **EXP** Expired: attrition to gingival margin with crown connecting all roots.
- **EXPRTR** Expired/retained tooth root: attrition to gingival margin with no crown present.
- **O** Missing/absent.
- **RD** Retained deciduous: caps.
- **FX** Fracture.
- **FX/SE** Sagittal: below gum line (subgingival) through infundibulum.
- **FX/WD** Wedge: outside infundibulum.
- **FX/CH** Chip: occlusal margin only. Not fractured down to gingiva.
- **IPM or D** Interproximal: between teeth. Mesial or distal.
- **B** Buccal.
- **P** Palatal.
- **L** Lingual.
- **TI** “Tooth impacted,” “blind”: not completely erupted. Partially or fully covered by bone or soft tissue. Commonly seen with wolf teeth.
- **RRT** Retained root tip: portion of root or tip retained.
- **RTR** Retained tooth root.

**Soft tissue:**
- **LAC/B** Buccal laceration.
- **LAC/L** Lingual laceration.
- **AB** Abrasion.
- **PD** Periodontal disease stage 1–4.
- **PP** Periodontal pocket.

**Other:**
- **INF/CA** Infundibular cavity.
- **CA** Caries.
- **SN** Supernumerary.

**Treatment and procedure abbreviations include:**
- **OD** Odontoplasty: reduction of excessive crown of occlusal surface.
- **I/OD** Incisor odontoplasty: incisor reduction.
- **FLT** Float: reduction of lingual and buccal enamel points.
- **BS** Bit seat: rounding of rostral margins of mandibular and maxillary 2nd premolars.
- **IFO** Infra-orbital nerve block.
- **MAX** Maxillary nerve block.
- **IFA** Inferior alveolar nerve block.
- **MEN** Mental nerve block.
- **LIP** Local infiltration of anesthetic.
- **X** Extraction, simple.
- **XS** Extraction, sectioned.
- **XSS** Surgical extraction.
- **506X, 606X, etc.** Cap extraction or retained deciduous extraction.
- **105X, etc.** Wolf tooth extraction.
tant feature of the chart). For example, a finding of hooks of the maxillary second premolars would be abbreviated by the author “106/206 HK.” Other examples of diagnostic abbreviations include the following:

- sharp enamel points (PTS)
- absent canine teeth (O/104/204/304/404)
- incisor bite deviation, ventral curvature (CV)
- laceration of buccal mucosa (LAC/B)

If the diagnostic codes are not adequately descriptive or intuitive for the knowledge level of the practitioner, an excellent pictorial aide in assigning diagnostic names and codes to various dental conformations can be found in Klugh’s *Principles of Equine Dentistry*. Consistency of diagnostic abbreviations is important so that another veterinarian can read the chart and understand the diagnosis and treatment plan. Dental conditions that affect the cheek teeth such as hooks (HK), ramps (RMP),

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**Fig. 1.** Completed chart from the author’s practice.
Key to Fig. 1.

Diagnoses:
- Diagonal incisors (DGL3)
- Midline discrepancy (MD) of 5 mm with mandibular 301/401 IP space shifted to maxillary 200 side
- Long canines 304/404
- Wolf teeth 105/205/305/405 not present (O/)
- Sharp enamel points (PTS)
- Hooks 106/206/311/411 (HK)
- Steps 110/210 (STP)
- Excessive transverse ridge 408 (ETR)
- Buccal lacerations/irritation associated with enamel points of 110/210 (LAC/B)
- Perio pocket 25 mm distal side of 108 (PP/IPD)

Treatments:
- Odontoplasty of incisors (I/OD)
- Odontoplasty of cheek teeth and canines as represented by solid red over tooth structure removed (OD)
- “Float” all sharp enamel points smooth (FLT)
- Minor contouring of mesial surfaces of 106/206/306/406 (BS)

Instructions to client:
- Recheck in one week to determine if quidding has ceased
- No feed for two hours after the procedure, then soft feed

Step-by-step dental chart instructions used by the author:

1. Name, date and physical exam findings recorded on the chart.
2. Presenting complaint, if any.
3. Specific drugs, exact amounts, and times of administration.
4. Gross examination findings of the head, including any nasal discharge or foul odors.
5. Observations concerning lips, gingiva, incisors, and canine teeth.
6. Distance of excursion to molar contact, before any treatment.
7. Observations concerning intra-oral condition of gingiva, lips, and cheeks.
8. Observations concerning cheek teeth and periodontium.
9. Any procedures and treatments performed such as nerve blocks, odontoplasty, extractions.
10. Indicate if any photographs and radiographs were taken.
11. Distance of excursion to molar contact after treatment.
12. Aftercare instructions and next exam/treatment time frame.

The author finds it beneficial to use dental charts made from NCR paper (no carbon required) so that the client can have a copy. Computer-generated charts may be printed or e-mailed to the client and/or referral veterinarian. The primary chart that the author uses for routine documentation includes a profile image of the entire skull and teeth with close-up diagrams of the incisors and canine teeth (Fig. 2). For more detailed annotation an ideal chart would include tooth drawings similar to those used in small animal dentistry to allow diagramming of any tooth surface. The secondary chart used by the author for more detailed annotation is taken from Baker and Easley’s *Equine Dentistry*, second edition (Fig. 3). Dacre’s rendering of the occlusal surfaces of the cheek teeth allows annotation of problems such as pulp exposure, infundibular decay, and periodontal problems involving any surface of the teeth, as well as various fracture conformations and misaligned or deformed teeth. The author prefers a modified version of the original published chart that depicts both maxillary and mandibular arcades, as viewed occlusally.

Charts can be handwritten or computerized. Computerized records obviate the use of paper and storage space and can be electronically transmitted to the client or referral equine dental specialist. There are a number of styles and layouts of equine dental charts that are commercially available, or you can develop your own version of a computerized or print chart. The basic template can be stored within a tablet device, filled out during the exam, and saved as a unique patient file.

3. Summary

It is the author’s opinion that a comprehensive oral health assessment and treatment plan should be part of the minimum standard of annual health care of all horses. The recording of this exam, procedures, and treatments employed are a legally
required part of the patient’s medical records. Knowledge of appropriate dental abbreviations and the Triadan nomenclature system of identifying individual teeth within the stomatognathic system are a required minimum for this process. The consistent and repetitious use of standardized abbreviations and terminology upon a form within a medical record system allows for quick concise record keeping and the ability of any medical care provider to understand the specific health conditions, diagnoses, and treatment plan for each individual patient. The equine dental chart can be filled out patientside in only a few moments to prevent confusion when treating more than one patient during any time frame. Computerized versions can even generate reminders for follow-up care, potentially increasing practice revenue, while at the same time ensuring compliance with state or country practice acts.

Fig. 2. Author’s basic dental chart.
**Acknowledgments**

**Conflict of Interest**
The Author declares no conflicts of interest.

**References**

3. Fig. 3. Supplemental occlusal chart on which periodontal pockets, fractures, cupped teeth, and endodontic problems may be charted. All dental quadrants are shown from the occlusal surface and surfaces are coded as B for buccal, P for palatal, and L for lingual. Pulp horns and maxillary infundibulae are represented.
How to Obtain a Diagnostic Radiographic Study of the Equine Cheek Teeth

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1. Introduction
The use of standardized radiographic views of the equine skull greatly facilitates interpretation of dental pathology. Digital radiographic systems are rapidly replacing traditional radiographic film in clinical equine practice. The methods for obtaining diagnostic radiographs of the equine cheek teeth with digital radiographic systems are presented. Standardized labeling and presentation are important for interpretation of skull radiographs.

2. Materials and Methods
Images presented were obtained with a digital system.

The American Veterinary Dental College and the American College of Veterinary Radiologists (ACVR) have differing conventions for radiographic presentation of extraoral dental radiographs. For the purposes of this paper, the ACVR presentation and labeling conventions are used.1 With regard to the head, lateral images are always presented with the horse’s nose facing the viewer’s left. The plane of the hard palate is used as the reference when considering angles of obliquity to the dorsal plane. Radiographic projections are described using the direction of travel of the primary beam, and for the purposes of this manuscript, the following terms and abbreviations have been utilized when naming radiographic views: left (L), right (R), ventral (V), dorsal (D), and oblique (O). A series of radiographs of the skull that enables evaluation of the entire dentition includes:

- Latero-lateral view: The right lateral view is obtained with the X-ray detector on the right side of the head (and the generator on the left side) and presented with the horse’s nose to the viewer’s left. A RIGHT label would be used.
- Dorsoventral (DV) views: The X-ray detector is positioned on the ventral aspect of the mandibles, and the central X-ray beam is directed perpendicular to the dorsal plane (the palate). The rostral aspect of the image is on the bottom, with the horse’s right side to the viewer’s left.
- Oblique views:
  - Left dorsal-right ventral oblique (LD-RVO) and right dorsal-left ventral oblique (RD-LVO). A LD30RVO is obtained with the X-ray generator on the horse’s left side and the X-ray detector on the right. The X-ray beam is directed in a left dorsolateral to right ventrolateral fashion, 30° to the dor-
sal plane. For comparison, the opposite oblique image should be obtained. This view will project the apical aspect of the maxillary cheek teeth closest to the X-ray detector. For example, the RD30LVO will project the apices of the left maxillary cheek teeth. For this view a LEFT marker would be used (and placed dorsal to the image). With the horse’s mouth opened for the RD30LVO view, the crowns of the left mandibular cheek teeth will be projected.

- Left ventral-right dorsal oblique (LV-RDO) and right ventral-left dorsal oblique (RV-LDO). A LV45RDO is obtained with the detector on the right side of the horse’s head and the generator on the left. In this image, the reserve crown-roots of the right mandibular cheek teeth would be highlighted. A RIGHT marker would be placed on the ventral aspect of the image. When the horse’s mouth is opened for the LV45RDO view, the apical portion of the right maxillary cheek teeth is projected.

- Intra-oral (occlusal) images of the maxillary and mandibular incisors are presented with the maxillary crowns down, mandibular crowns up, and the horse’s right to the viewer’s left.2

While the straight lateral and DV views are obtained with the mouth closed, the lateral oblique views are obtained with the mouth held wide open with a speculum or a bite block. The speculum used by the author does not significantly interfere with imaging of the cheek teeth. The open-mouth positioning of the oblique projections eliminates much of the superimpositioning of the cheek teeth. More importantly, these projections of the apical aspect of the maxillary cheek teeth and the coronal aspects of the mandibular cheek teeth in the space between the maxillary and mandibular arcades provide excellent dental detail, comparable to the images obtained with intraoral placement of the detector using a computed radiography (CR) system (Figs. 2 and 3). The increased apical detail of the maxillary cheek teeth with the open-mouth oblique views (LV45RDO and RV45LDO) compared with the other oblique views (RD30LVO and LD30RVO) is due to the fact that the X-ray beam is passing through only one maxilla in the former, as compared with both maxillae in the latter.

3. Results

The lateral image (Fig. 1) is used primarily to evaluate the paradental anatomy. The paired sinus structures are superimposed in the lateral image; therefore, laterality of the sinus pathologic change is not possible. However, fluid lines and soft tissue masses within the sinus spaces are readily appreciated (Fig. 2). In the oblique views (LD30RVO and RD30LVO), images of the right and left sinuses are separated which facilitates evaluation of these structures and localization of pathology (Fig. 3).
The DV view can also be used to evaluate the sinuses, as the most lateral aspects of the rostral maxillary sinus (RMS) and the caudal maxillary sinus (CMS) project laterally of the maxillary molars (Fig. 4). Sinus cysts, ethmoidal hematomas, and neoplasms within the sinuses may also be evident as soft tissue densities between the mandibles in the DV views, often with displacement of the vomer. The offset mandible DV will provide improved separation of the mandibular and maxillary arcades (Fig. 5). Due to the angulation of the rostral and caudal cheek teeth, when the central-ray beam is directed perpendicular to the dorsal plane, it will be parallel to the long axis of only the middle 4 cheek teeth. This results in loss of detail of the rostral and caudal cheek teeth in this image.

Evaluation of the cheek teeth requires multiple projections, as the crown and reserve crown-root often cannot be evaluated well in a single image. The three roots of the maxillary cheek teeth are generally difficult to separate and identify radiographically. In the oblique view (LD30RVO or RD30LVO), the buccal roots can usually be identified, but the palatal root is often obscured (Fig. 6). The opposite oblique image of the maxillary apices, the open-mouth oblique views (LV45RDO or RV45LDO), will sometimes isolate the palatal root (Fig. 7). In young horses, the length of the reserve crown may make it difficult to isolate the maxillary cheek teeth apices in the interdental space in the ventrodorsal oblique (LV45RDO or RVLDO) image.

The radiographic appearance of the roots of the cheek teeth vary significantly with the horse’s age. The mandibular cheek tooth roots lengthen with age, whereas the maxillary cheek tooth roots usually do not lengthen as significantly. Periodontal disease clinically associated with senile diastemata, feed packing, and tooth mobility may be accompanied by radiographic signs such as widened periodontal ligament space, apical alveolar bone lysis (“halo”), periapical alveolar bone sclerosis (condensing osteitis) and tooth root blunting (Fig. 8). Similar radiographic signs are also evident with endodontic disease in the young adult horse (Fig. 9).

Idiopathic crown, reserve crown, and crown-root fractures are seen in both young and older horses. While the etiology often is undetermined,3,4 radiographic evaluation is important in treatment planning.5 As an example, consider the 17-year-old Quarter Horse mare presented for evaluation of crown fractures of the left mandibular 4th premolar (308) and the right mandibular 2nd molar (410) (Fig. 10). Oral examination revealed a slab fracture of 308, through pulp horns #1 and #2, with buccal displacement of the fragment, and a slab fracture (missing the fragment) of 410, also through pulp horns #1 and #2. The oblique views (LD30RVO and RD30LVO) were useful for imaging the crowns of the fractured mandibular teeth (Figs. 10A and 10B), while the LV45RDO and RV45LDO views were necessary for evaluating the reserve crown-roots of these teeth (Figs. 10C and 10D). The benefit of open-mouth lateral oblique positioning is well-demonstrated by this case.
4. Discussion

The radiographic anatomy of the head is complex with superimposed symmetrical anatomy. Radiographic evaluation of the teeth is often difficult with subtle findings correlating to clinical disease. The widespread use of digital radiography and higher kilovoltage (kVp), milliamperage (mA) portable generators has enabled the practitioner to obtain images with good radiographic technique. However, many practitioners have little experience with the radiographic and patient positioning for studies of the cheek teeth. Correct radiographic positioning is paramount for the interpretation of dental and paradental disease. A full study of the skull is required to make a diagnosis. This includes:

- Dorsoventral view
- Latero-lateral view
- Right dorsal-left ventral oblique (RD30LVO), open-mouth
- Left dorsal-right ventral oblique (LD30RVO), open-mouth
- Right ventral-left dorsal oblique (RV45LDO), open-mouth
- Left ventral-right dorsal oblique (LV45RDO), open-mouth

Figs. 1–6 assume the use of a 10 by 12 inch imaging plate/sensor which, if positioned correctly, will capture all 4 arcades in each view. Supplemental views will be necessary with smaller plates/sensors.

Fig. 5. DV image with mandible offset to the left (10-year-old Quarter Horse mare, cadaver). This patient positioning allows better visualization of the right maxillary and mandibular arcades.

Fig. 6. The RD30LVO projection is used to image the apices of the left maxillary and the crowns of the left mandibular cheek teeth (10-year-old Quarter Horse mare, cadaver). Note that the right maxillary crowns are also imaged in the interarcade space and that in this image the right maxillary 3rd molar (111) is projected caudal to the left maxillary 3rd molar. All three roots of the left maxillary cheek teeth can be readily identified only for the 2nd and 3rd premolars (arrows).

Fig. 7. The LV45RDO view of a 10-year-old Quarter Horse mare (cadaver). With the mouth wide open, the right maxillary cheek teeth are isolated in the space between the left maxillary and mandibular arcades, which gives apical detail similar in quality to that obtained with intraoral projections only possible with some CR systems. In this view, the broad, thin, palatal root (*) of the right maxillary 1st molar (109) is projected dorsal to the buccal roots. The same positioning is used to image the apical portion of the right mandibular cheek teeth (406–411).
or if positioning is not optimal. The addition of offset mandible and intraoral views of the incisors and canine teeth is case-dependent. The use of all 6 of these views allows for evaluation of each cheek tooth from several angles and is analogous to obtaining 4 to 5 views in a fetlock joint study with the same views of the contralateral limb for comparison. Standardization of the study has the benefit of permitting the radiologist to readily recognize when the view is appropriately positioned, speeds up the radiographic examination, and enhances the ability to obtain a diagnosis or seek a consultation from a specialist. Digital systems allow the radiologist to obtain this study quickly. The author recommends presenting this service as a study billed similarly to a distal extremity study in a lameness examination (Equine dental radiographic study: $200–300) rather than billing by the image, which tends to result in the client requesting fewer images than are needed for a complete assessment and treatment planning.

Fig. 8. RV45LDO radiograph of a 22-year-old Tennessee Walking Horse mare. There was feed packing in diastemata between the left and right maxillary 3rd and 4th premolars and 1st molars. Periapical bone lysis (arrow) is evident on the distal buccal root of the left maxillary 3rd premolar (207). Note the short roots of the maxillary cheek teeth in comparison to the mandibular cheek teeth.

Fig. 9. An 8-year-old Holsteiner gelding with a complicated crown fracture of 408 associated with right ventral mandibular swelling and a draining tract. There is periapical sclerosis and apical bone lysis (arrows) associated with the fractured 408 (A) as compared with the contralateral 308 (B). Courtesy of Leah Limone, DVM.
Fig. 10. In the clinical examination of a 17-year-old Quarter Horse mare, a complicated crown (buccal slab) fracture of the left mandibular 4th premolar (308) and the right mandibular 2nd molar (410) were identified. Multiple views were required to obtain a complete radiographic assessment. (A) LD30RVO open-mouth lateral view demonstrates the fracture of 410 (arrow). In the RD30LVO view (B), the transverse fracture of 308 is evident (arrows). In the RV45LDO view (C) the distal root of 410, which was poorly imaged in the LV45RDO view (D), is isolated and exhibits a widened periodontal ligament space (arrow). (D) the LV45RDO view reveals the widened periodontal ligament space of the mesial root of 410 (black arrow). The distal root of 410 (white arrow) lacks adequate detail in this view. Note that 308, isolated in the interarcade space, also nicely exhibits the transvers reserve crown fracture (red arrow). There is no radiographic evidence of periodontal disease associated with the 308 reserve crown fracture in this study.

Acknowledgments

Conflict of Interest

The Author declares no conflicts of interest.

References and Footnotes


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How to Utilize Advanced Imaging in the Management of Equine Dental Cases

Jeremiah T. Easley, DVM, MS, DACVS*; and Jack Easley, DVM, DABVP

1. Introduction
Equine dental cases are challenging. All cases require a complete and thorough oral examination that often leads to routine radiographic imaging in order to establish a diagnosis. In selective cases, more advanced diagnostic imaging such as nuclear scintigraphy (NM), computed tomography (CT), or magnetic resonance (MR) imaging enhance the clinician/surgeon’s ability to clearly define the problem and plan treatment. Sensitivity and specificity of radiography for dental disease ranges from 52 to 69% and 70 to 90%, respectively.1,2 While radiographs are the most common and easily accessible imaging modality utilized in equine dentistry, accurate interpretation is difficult due to the complexity and summation of anatomic structures. Radiography is often the only imaging modality available and frequently yields an immediate diagnosis. On the contrary, further advanced imaging may be required in patients that are recalcitrant to medical therapy, require extensive surgical intervention, or have a disease that involves more than one tooth. As a general practitioner, it is important to understand the limitations of radiography to clearly diagnose equine dental disease. Advanced imaging may be employed to better characterize the extent and exact location of the abnormality, thus allowing a more effective treatment.

2. Materials and Methods
Advanced Diagnostic Modalities
A complete physical and oral examination must be completed prior to performing any imaging in patients with suspected dental disease. A proper oral examination must include the use of a mouth speculum, a light source, and a dental mirror or oroscope on a properly restrained and sedated horse. It is nearly impossible to have an accurate diagnosis from an oral examination without the appropriate instrumentation. If dental-related disease is suspected, a complete series of skull radiographs is the next step in the course of confirming a diagnosis prior to advanced imaging.3

When deciding whether to perform advanced imaging in dental cases, it is important to realize that NM, CT, and MR do not guarantee a precise diagnosis. On the contrary, advanced imaging is acceptable to perform even on cases where a fairly confident diagnosis has been made through other modalities. Dental disease can be perplexing to diagnose and treat with the potential for complications. Performing invasive dental surgery without
an accurate diagnosis and complete understanding of the pathological process can lead to long-term complications such as chronic oro-nasal, -sinus, and -cutaneous fistulas that are extremely difficult to resolve. It is the authors’ opinion that invasive surgical treatment of dental related disorders not be performed until there is confidence in the diagnosis. Advanced imaging can only strengthen a clinician’s confidence in a diagnosis, resulting in a well-constructed and precise treatment regime for the horse. While advanced imaging is significantly more expensive compared to other diagnostic tools, the financial cost of inaccurate diagnoses and/or treatment can oftentimes result in higher overall costs to the owner and morbidity to the horse.

Prior to referral for advanced diagnostic imaging, it is important to understand the differences between NM, CT, and MR and their advantages and disadvantages (Table 1).

3. Results

Nuclear Scintigraphy

Nuclear scintigraphy images reflect physiologic rather than anatomic structure and are highly sensitive to bone turnover.4 The sensitivity and specificity of scintigraphy has been reported at 95% and 86%, respectively.1 When radiographs and scintigrams were concurrently evaluated, the sensitivity and specificity for detection of dental disorders increased to 97.7% and 100%, respectively.3 One advantage to NM is the ability to perform imaging in the sedated standing horse. This is obviously better for the horse by avoiding general anesthesia. However, since NM does not provide multiplanar images, anatomical understanding is challenging and fails to improve the diagnosis of secondary disease such as sinusitis or fistulas. At $400 to 700 for a focused exam of the skull in cases of suspected dental disease, the authors feel that NM should be reserved for cases where CT or MR imaging are not available, general anesthesia must be avoided, or where an accurate diagnosis is unobtainable by either modality.

Computed Tomography

Computed tomography has played a pivotal role in the diagnosis and effective treatment of equine dental and sinonasal disorders.5–9 Computed tomography acquires radiographic skull images in the transverse plane and a complete examination can be performed in approximately 15 min. Postacquisition reconstructed images can then be made in any plane or into three-dimensional images for surgical planning and owner/client education. New software can even allow 3-D printers to construct scaled down versions of the skull or dental tissues. Computed tomography allows for evaluation of the skull without anatomic superimposition and provides excellent contrast and spatial resolution. For these reasons, CT provides a more accurate assessment of the extent and physical features of diseases of the skull than conventional radiographs. Both soft tissues and bone can be imaged with CT. However, the soft tissue contrast resolution of MR imaging is superior to CT. An important function of CT is the measure of tissue attenuation (radiopacity) in Hounsfield units (Table 2). This can help differentiate pure fluids from soft tissue masses. Common CT features of dental disease include widening of the periodontal space, tooth root lysis/blunting, tooth crown or root fragmentation, alveolar bone sclerosis, and apical tooth root gas.5,8

Computed tomography imaging has traditionally been performed with the horse under general anesthesia. More recently, a handful of imaging facilities around the world allow CT examinations to be performed in the standing sedated horse. This technique is becoming increasingly popular. Standing CT will allow veterinarians and owners the opportunity to perform advanced imaging safely.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Hounsfield unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enamel</td>
<td>2400–2600</td>
</tr>
<tr>
<td>Dentin</td>
<td>1600–1800</td>
</tr>
<tr>
<td>Cementum</td>
<td>1200–1500</td>
</tr>
<tr>
<td>Bone</td>
<td>1000</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>40–60</td>
</tr>
<tr>
<td>Brain</td>
<td>30–40</td>
</tr>
<tr>
<td>Water</td>
<td>0</td>
</tr>
<tr>
<td>Fat</td>
<td>–100</td>
</tr>
<tr>
<td>Air</td>
<td>–1000</td>
</tr>
</tbody>
</table>

Table 1. Comparison of Nuclear Scintigraphy (NM), Computed Tomography (CT), and Magnetic Resonance (MR)

<table>
<thead>
<tr>
<th></th>
<th>NM</th>
<th>CT</th>
<th>MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expense</td>
<td>$400–700</td>
<td>$500–1200</td>
<td>$2000–2500</td>
</tr>
<tr>
<td>Requires anesthesia</td>
<td>No</td>
<td>Yes/No</td>
<td>Yes</td>
</tr>
<tr>
<td>Multplanar images</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Anatomic bone detail</td>
<td>Variable</td>
<td>High</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>Anatomic soft tissue detail</td>
<td>Variable</td>
<td>Minimal</td>
<td>High</td>
</tr>
<tr>
<td>Physiologic information</td>
<td>Yes</td>
<td>No</td>
<td>Variable to yes</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>Low (256 × 256)</td>
<td>–1 mm slices</td>
<td>Moderate (320 × 290 matrix)</td>
</tr>
<tr>
<td>Contrast resolution</td>
<td>N/A</td>
<td>Moderate</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 2. Hounsfield Units of Tissues
with decreased costs and risks. In the authors’ opinion CT imaging is the gold standard advanced imaging modality in equine dentistry and will continue to increase in its importance and value as standing CT becomes more popular and accessible.

Magnetic Resonance Imaging
While MR imaging is more commonly utilized for the diagnosis of soft tissue and musculoskeletal injuries, it can be advantageous in the diagnosis of dental disease. Unlike CT and radiographs that base images on attenuation, MR images are based on the signal measured from spinning magnetic moments of the hydrogen nuclei. When describing MR images, findings are referred to by signal intensity, often relative to muscle or normal areas of soft tissue. Low signal intensity is black and consistent with cortical bone, teeth, air, tendons, ligaments, and some stages of hemorrhage. High signal intensity is white and generally consistent with fat on sequences that do not have fat suppression. Other soft tissues are shades of grey, depending on their magnetic properties (Table 3).

There are few publications specific to MR findings in equine dental disease. Most literature focuses on the normal anatomy of structures of the skull and pathologic changes in the brain and pharynx. As previously mentioned, MR imaging provides great soft tissue contrast (Fig. 1). However, teeth are void of signal in conventional MR imaging. More recently, human studies are utilizing new techniques to allow both the solid and soft tissue component of teeth to be imaged for dental and maxillofacial applications. These new techniques may eventually make a place for MR imaging in equine advanced imaging for dentistry. Gerlach et al describes equine MR pulp abnormalities as blurred with a lower signal intensity.

An MR examination is considered relatively expensive at $2500/scan. Examinations of the skull are performed under general anesthesia and scan

<table>
<thead>
<tr>
<th>T1 Weighted</th>
<th>T2 Weighted</th>
<th>STIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Cortex</td>
<td>Very low signal (black)</td>
<td>Very low signal (black)</td>
</tr>
<tr>
<td>Bone Marrow</td>
<td>High signal (white)</td>
<td>High signal (white)</td>
</tr>
<tr>
<td>Fluid (low protein)</td>
<td>Iso signal (grey)</td>
<td>High signal (white)</td>
</tr>
<tr>
<td>Fluid (high protein)</td>
<td>High signal (white)</td>
<td>Low signal (grey)</td>
</tr>
<tr>
<td>Fat</td>
<td>High signal (white)</td>
<td>High signal (white)</td>
</tr>
<tr>
<td>Dentin</td>
<td>No signal</td>
<td>No signal</td>
</tr>
<tr>
<td>Enamel</td>
<td>No signal</td>
<td>No signal</td>
</tr>
<tr>
<td>Cementum</td>
<td>No signal</td>
<td>No signal</td>
</tr>
<tr>
<td>Pulp</td>
<td>Iso to high signal (grey to white)</td>
<td>Iso to high signal (grey to white)</td>
</tr>
</tbody>
</table>

Fig. 1. Transverse CT (left) and MR (right) image of the same horse at the level of the 1st molar. Notice the range of contrast in the MR image compared to the CT.
times range from 45 to 120 min. Magnetic resonance imaging should be considered an alternative imaging modality when CT imaging is unavailable. The authors have found this modality to be beneficial in the diagnosis of dental disease, but less accurate in challenging cases of dental disease than CT due to the decreased spatial resolution and void of signal within teeth.

4. Discussion and Summary

Nuclear scintigraphy is considered an advanced imaging modality that has been shown to improve the ability to accurately diagnose equine dental disease. It should be reserved to cases where general anesthesia must be avoided or CT and MR imaging are not available.

Unlike NM, multiplanar imaging, such as CT and MR, have advanced our understanding of functional anatomy not only in the skull, but throughout the entire equine body. The ability to noninvasively “look inside” anatomical structures has revolutionized veterinarians’ ability to diagnose and treat equine diseases. The equine skull is one of the most complex anatomical structures and intercommunication between the teeth, bones, maxillary sinuses, and nasal cavities make disorders of the equine skull difficult to diagnose and successfully treat.

In the authors’ opinion, CT is the most valuable advanced imaging modality in the diagnosis of dental disease. With the advent of standing CT, this modality is becoming increasingly more valuable, less expensive, and safer for the horse. If you consider the cost of a complete radiographic series of the skull to be approximately $300, a standing CT examination of $600 is extremely beneficial and, when available, could potentially replace radiographic examination in cases where financial constraints exist. The additional cost of the CT examination outweighs the risk of potential misdiagnosis and inappropriate treatment. Magnetic resonance imaging can often provide similar diagnostic capabilities in equine dental disease, but should be reserved for cases where CT is nondiagnostic and/or unavailable, or improved soft tissue contrast resolution is required.

The decision to utilize advanced diagnostic imaging in cases of dental disease should be similar to the decision process of referring a colicky horse for surgery. Veterinarians consider referral based on the severity and complexity of disease, financial constraints of the owner, experience/comfort level of the clinician, and the risks of an inaccurate diagnosis/treatment plan. An inaccurate diagnosis or treatment plan can lead to increased morbidity or even mortality. As with referral of colics, advanced diagnostic imaging in cases of dental disease can only lead to greater understanding of the disease, resulting in improved outcomes for the horse and client.

Acknowledgments

Conflict of Interest

The Authors declare no conflicts of interest.

References

How to Incorporate Nutritional Discussions and Nutritional Alterations As Components of Equine Dental Care

Caroline N. Niederman, VMD, FAVD, Equine

1. Introduction

The purpose of this paper is to outline an approach that incorporates both nutritional assessment and dietary modification into a program of regular equine dental care. The annual oral examination provides the equine practitioner with the opportunity to not only identify common dental abnormalities (periodontal, endodontic, and occlusal) but also to document the loss of cheek-teeth chewing surface area that occurs with age as a product of normal dental eruption and wear.1,2

A complete oral examination begins with taking a dental history. This is followed by patient observation, an extra-oral physical examination, and finally the oral examination.3 Findings are documented on the dental record. Important nutritional information can be obtained at each phase to give the equine practitioner a clear picture of how the horse is handling its current diet, especially hay. Such monitoring of this progressive process gives the equine owner early awareness of impending dental and nutritional issues and allows implementation of dietary modifications prior to any significant weight loss or more serious choke or impaction events.

2. Materials and Methods

The dental history should focus on determining what the horse is fed, how the food is delivered, and how it appears to be meeting the horse's nutritional needs; in particular, its caloric requirements. Questions should include:

- What do you feed your horse? How often? Is there access to pasture?
- Is your horse still able to eat hay? Does the horse leave any undigested boluses of hay?
- Where is the horse fed? Is the horse separated from other horses when it feeds?
- How long does it take for the horse to finish eating?
- Has the horse gained or lost weight over the past year?
- What do the fecal balls look like? Formed and moist? Dry? Presence of undigested hay?
- Is your horse on any medication(s)?

Observing the horse allows the equine practitioner to assess the animal's body condition, eating habits (i.e., the ability to prehend food and any evidence of quidding hay), and fecal consistency.
The results of the initial extra-oral physical examination can provide another, albeit superficial, indication of possible underlying issues (i.e., heart murmurs, anemia, long hair coat suggestive of pituitary dysfunction) that may warrant further workup.\(^1,2\) The diets of many senior animals are high in molasses (for palatability) and protein, both of which may be contraindicated for horses with pituitary dysfunction or advanced liver abnormalities.\(^4\)

The oral examination, from a nutritional perspective, should focus on the evaluation of the occlusal surface of the cheek teeth to identify the progressive loss of infundibular enamel in the maxillary cheek teeth and enamel infolding in the mandibular cheek teeth. Enamel loss decreases the chewing surface area used to masticate hay (Fig. 1).\(^5,6\) The term “smooth mouth” describes teeth experiencing this process: teeth without the infundibular or central enamel.\(^1,2,5,6\) Maxillary cheek teeth are referred to as “cupped teeth” when their clinical (exposed) crown is worn below the apical extent of the infundibulae, but still have clinical crown above the gingival margin. Mandibular cheek teeth similarly lose the normal enamel infolding in the center of the tooth, but there is no specific term for this. The occlusal surface of the center of both maxillary and mandibular teeth is smooth and concave in appearance. The loss of enamel exposes the underlying cementum and dentin, both dental tissues with little wear resistance, so these teeth quickly undergo fur-
ther attrition. “Expired” describes maxillary or mandibular cheek teeth at the end stage of smooth mouth, where the teeth are worn down to the cemental root remnants.5,6

All levels of attrition need to be documented in the dental record. Adding drawings and color to the written record is useful to visually reinforce the loss of surface area (Fig. 2). The next important step is to educate the owner by showing them the changes observed during the examination. Intra-oral photos and drawings can also be used to reinforce the findings for both present and absentee owners.

On the dental record the entire tooth is filled in when it is expired (end-stage smooth mouth). The author’s computer program allows for manipulation of the tooth height so the loss of clinical crown can also be depicted (Fig. 3A). The tooth could instead be marked with a line, as shown in Fig. 3B, to denote this same loss (Fig. 3).

3. Discussion
With most equine practitioners seeing a growing number of geriatric patients, it can be valuable to incorporate proactive nutritional discussions into the examination routine. Nevertheless, appropriate nutritional advice is not possible until all aspects of the clinical examination (dental history through oral examination) have been completed.

Completion of the dental history in combination with a look at conditions at the stable or private residence can often indicate the immediate cause of observed weight loss. For example, the thin geriatric horse scheduled for examination may be the one seen standing out in a paddock with a round hay bale along with the other younger and fatter horses. That older horse’s teeth are simply unable to chew the hay and, thus, that horse can only stand aside as the others feed. Another common scenario is that the owner has called for an appointment because, despite eating 20 lb of a senior feed each day, the horse is still thin. In the latter situation, it may be useful to find out how long it is taking the horse to eat each feeding. A good rule of thumb to use is that if a horse takes longer than 45 min to finish each meal, switching to a more calorically dense feed is warranted.

The observation and extra-oral physical examination is also an opportunity to determine if further diagnostics may be warranted either before or after the horse is sedated for the oral examination. A routine complete blood count (CBC), chemistry, and other specific endocrine testing could identify the presence of anemia or liver, kidney, or pituitary dysfunctions that may influence the final nutritional recommendations.

The oral examination is the most valuable tool for evaluating how well the horse, as it ages, can chew hay. Documenting the level of wear present in a horse’s mouth is important because many horse owners have the false belief that horse’s teeth grow...
over time and since many geriatric horses require minimal dental corrections, owners often have an unjustified sense of security regarding their horses’ nutritional needs. This misconception can be corrected by talking to owners about eruption and wear once cupping is identified in the maxillary first molars. The progressive nature and pattern of the wear can be emphasized by using dental eruption charts as visuals (Fig. 4). Dietary recommendations should be a part of these conversations before the horse has lost weight and its mouth looks like that depicted in Fig. 5. Owners should be asked to start watching for signs of undigested hay (quidding) when the upper 09s and 10s are cupped. When all the maxillary 09s, 10s, and 11s are either cupped or expired a long-stem hay alternative should be found, especially if pasture is not readily available. For senior horses with greatly diminished chewing function such as the horse in Fig. 5 (assuming lab work has precluded problems such as renal or hepatic dysfunction), chopped or soaked grass and grass/alfalfa-mix hay cubes fed at a rate of 1.0 to 2.0% of body weight per day; a senior feed (crude protein: 12–14%; crude fat: 8–20%; crude fiber: 5–10%), and possibly the use of edible oil up to 1 cup/day or rice bran (0.5–1.0 lb/day), again assuming normal hepatic function, to increase the digestible energy if the horse needs to gain weight.1,2

4. Summary
The routine oral examination presents an opportunity to improve client awareness of the significance of age-related tooth wear and to discuss proactive dietary modifications to prevent cases of choke, impaction, and dramatic weight loss as the horse ages. In most instances, proper nutritional advice can be obtained by performing a thorough dental history, examining the horse, evaluating the stable environment, observing the horse’s eating habits, and analyzing a fecal sample. Lab work may be indicated as part of the evaluation to rule out underlying disease conditions.

Acknowledgments
Conflict of Interest
The Author declares no conflicts of interest.

References