# Associated Risk Factors of Equine Odontoclastic Tooth Resorption and Hypercementosis

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We suspect that a painful disease involving the equine incisors and canines called equine odontoclastic tooth resorption and hypercementosis (EOTRH) does not have a single determinant but rather occurs as the result of the cumulative impact of several risk factors: trauma caused by excessive dentistry, periodontal disease, type of feed, genetics and hormonal conditions such as equine Cushing's disease (pituitary pars intermedia dysfunction; PPID) and equine metabolic syndrome, and the presence of laminitis. Authors' addresses: Reata Equine Veterinary Group, 9100 East Tanque Verde, No. 100, Tucson, AZ 95748 (Pearson, Mansfield, Conaway); Eller College of Management, University of Arizona, 1130 East Helen Street, Tucson, AZ 85721 (Koput); e-mail: annpearson1960@yahoo.com. *Corresponding and presenting author. 

## 1. Introduction

Equine odontoclastic tooth resorption and hypercementosis (EOTRH) has been described in several publications as a painful disease affecting primarily the incisors and canine teeth.[1–4] In our experience, on gross inspection, the teeth appear as bulbous, irregular, and lytic inside. Gingival receding is often seen along with shifting of incisor positioning (Fig. 1). The radiographic findings include radioopaque densities involving the alveolar tooth roots, shifting of the teeth, osteomyelitis of the alveolar and surrounding bone, and widened periodontal spaces. Similar findings have been reported in the past in which on radiography, the teeth may appear as having bulbous enlargement with or without resorption.[2,3,5]

Recent literature has proposed that horses more than 15 years of age[1–4] and breed predilection such as Thoroughbreds and Warmbloods[6] may be risk factors associated with the incidence of EOTRH. Increased age has been previously noted as a cause of periodontal disease because of a loss of reserve crown and increased interproximal spaces.[7]

In addition to the amount of mastication time, efficient mastication is needed to prevent periodontal disease. Exposure of enamel ridges on the occlusal surface and preventing excessive tooth wear is needed for efficient mastication.[8] It was theorized that by excessive reduction of incisors and cheek teeth, the efficiency of mastication would be decreased. Trauma as a whole when dentistry is performed excessively or by some unlicensed dentists may also weaken the periodontal ligaments. The horses with excessive dental procedures may have a predisposition for lack of salivary bathing time caused by the lack of ridges left after aggressive floating. Our hypothesis is that excessive dentistry may be a risk factor in the development of EOTRH.

Initially, the proposed etiology of EOTRH was thought to be secondary to dental disease, whereby

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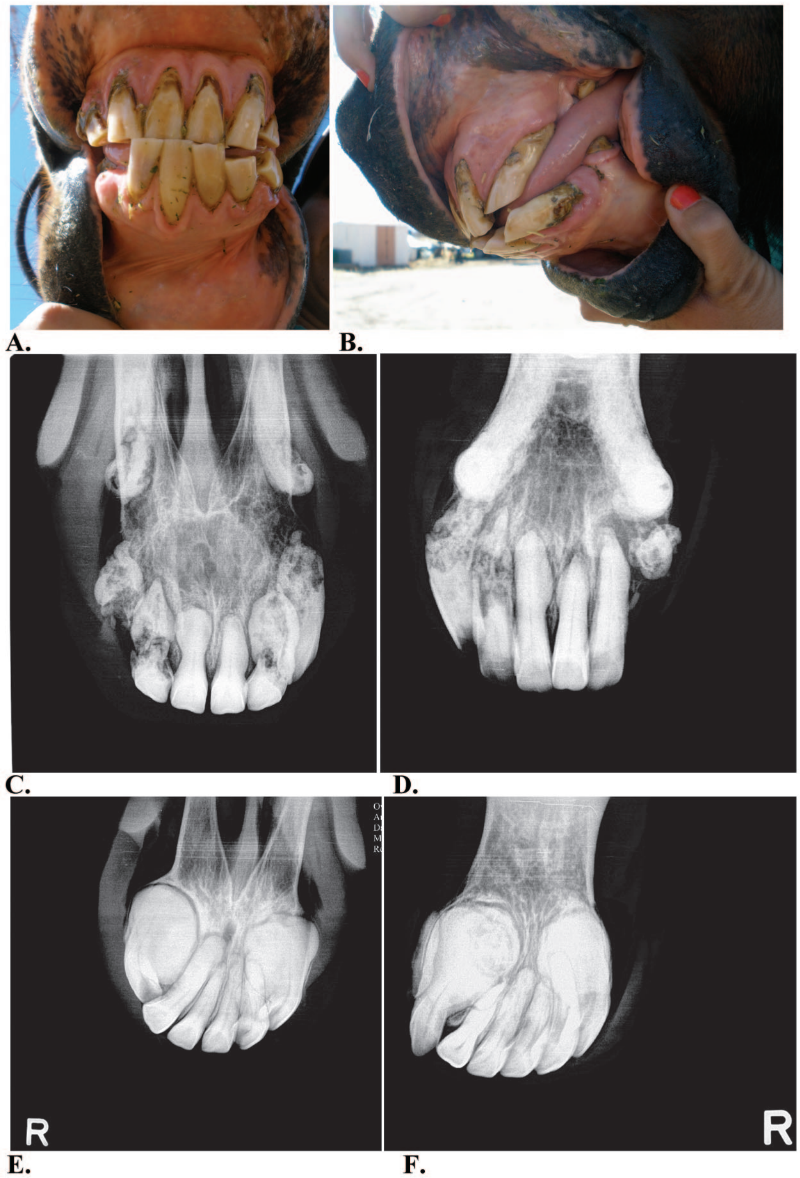


Fig. 1. Images show incisor drifting and gingival recession (A and B) in a 20-year-old Thoroughbred gelding with history of excessive dentistry (incisor and canine reductions). Radiographs of the same horse are shown of the maxillary (C) and mandibular (D) incisors showing resorption and lysis of teeth and bone. Radiographs were taken from a 24-year-old Quarter Horse mare with minimal outward clinical signs (history of avoidance behavior around her mouth). Both maxillary (E) and mandibular (F) incisors exhibit severe hypercementosis of the corner incisors, resulting in crowding of central incisors and loss of rostral incisive and mandibular bone. F, Remnant of canine 304 is superimposed over 303.

the inflammation of the periodontal ligaments were instrumental in the cause of resorptive lesions in calcified incisors.[2,9] Studies were performed by Stazyk in 2008, whereby the diseased teeth were analyzed histologically and grossly. The surrounding cementum was histologically different in affected teeth when compared with normal teeth. The type of collagen fibers as well as the arrangement and size of blood vessels were different. The arrangement of fibers were disordered, and the vascular channels were large within the diseased cementum. An independent variable asked on the retrospective study involved the question of whether or not the horse had ever been on pasture. It is possible that the lack of grazing with the associated tug and tearing motion and lack of movement with the incisors may be associated with a stagnant effect, thereby producing a venous congestion with enlarged vascular channels and lack of blood pumping into the gums. Our hypothesis is that the presence of periodontal disease is a risk factor that may be a predictor of future EOTRH. The development of periodontal disease may be multifactorial and may not only include lack of blood supply to the gums but also lack of salivary bathing time and hormonal influences.

Reducing food stasis is very important in preventing periodontal disease. Preventing dental interlocks and promoting normal movement of mastication aids in the bathing with saliva.[10] According to Gieche,[10] horses rely on normal salivary bathing of the periodontium and continual movement of food matter through swallowing. By increasing pasture or grass hay, an increase in masticatory time will be instituted. We are hypothesizing that the lack of grazing time will not allow the horse to have the head down in proper position to allow the saliva to have the full effect of bathing the incisors and removing stagnant feed.

The associated evidence of endocrine disorders with accompanying laminitis has been studied as to the mechanisms involved.[11] With the equine metabolic syndrome (EMS) present in several horses, it is possible that the glucose and insulin levels in the blood are much higher and may be associated with the periodontal disease that was present in these horses. In several studies, as will be discussed, the end results of EMS on laminitis include vasoconstriction, thrombosis, and catabolism of laminar proteins.[12] All risk factors should be considered with the anatomical structures around the tooth. It has been found that the tooth actually fits into a fibrous socket called a gomphosis.[10,13] The joint consists of cementum (which is a living tissue),[14] periodontal ligament, bone lining of the alveolus, and gingival that is facing the tooth. In small animals, recent research indicates that there is a much higher prevalence of ligament laxity with associated canine Cushing's disease, presumably because of the hormonal effects of cortizol.[15] It has been widely acknowledged that horses with pituitary pars intermedia dysfunction (PPID) and EMS are much more predisposed to infection. It is hypothesized that horses with clinical signs of PPID, EMS, and laminitis may be more at risk for development of EOTRH. The hormonal effects of cortizol may weaken the periodontal ligaments, and the high levels of glucose and insulin in the blood may affect essential components of the cementum and periodontal ligament adversely, thereby increasing the risk of periodontal disease. The risk factor of horses that have been diagnosed with hormonal diseases such as PPID and EMS with associated laminitis are hypothesized to be of significant value.

## 2. Materials and Methods

We used detailed medical records on more than 13,000 veterinary calls involving 3461 horses over a 12-year period for an equine veterinary group located in the desert southwest to conduct an archival study that matches the statistical characteristics of a prospective, repeated-measures, longitudinal field study. Horses were included in the analysis on the basis of having been visited by a veterinarian in the group for any reason from 2000 to 2012. Horses were then followed at each subsequent visit by any vet in the group for the duration of the study period or until the horse was no longer a patient. Content analysis was used to code the notes attendant to each visit for key terms indicative of the outcome and risk factors, as illustrated in Table 1. Risk factors were age, breed, sex, lay dentist, incisor reductions, pasture history, PPID, EMS, presence of periodontal disease, signs of involvement with water (playing, standing by the water tank, etc), salivation, laminitis, and the exclusive history of feeding alfalfa.

**Table 1. Examples of Terms Used in Content Analysis of Medical Records**

| Variable | Example Key Terms |
|---|---|
| Excessive dentistry | Lay dentist, incisor reduction |
| Dental disease | Periodontal disease |
| Low-mastication feed | Alfalfa, not pasture, not grazing |
| Endocrine | Cushing's disease, PPID, Prascend,[b] crested neck, EMS, metabolic syndrome, fatty deposits, laminitis |
| External/behavioral symptoms | Excess salivation, drooling, mouthing water bucket |

Control variables, such as age, breed, and sex, were coded from extant fields in the veterinary group's database. We then performed logistic regression analyses to test for the predictive relationships between risk factors and outcomes entailed in our hypotheses. For the regressions, we restricted our analyses to horse-visit records up to and including the first incidence of the outcome and used statistical corrections for the non-independence of observations inherent in any repeated-measures design.

To gain further insight into and validate the measurement of the outcome in our prospective study, we also conducted a retrospective study on 20 cases in which the outcome was identified. This study involved a clinical examination, radiographs before tooth extraction, and a questionnaire given to the horse owners. The clinical exam included examination of the teeth, evaluation for regional adiposity, presence of long haircoat, and overall body condition. When evidence of EOTRH was present, radiographs were advised, and those patients in the study had radiographs taken before surgical tooth extraction. The questionnaire involved 16 questions covering the risk factors, symptoms, and history items revealed as important in the statistical analyses.

## 3. Results

Our sample consisted of 3461 horses, ranging in age from 1 to 40 years, covering more than 70 breeds and with a mix of mares, geldings, and stallions. The average age was 9.3 years. Nearly a third of the sample were Quarter Horses, with another fifth be-

**Table 2. Describing Risk**

| | Entire Sample | Coded as EOTRH |
|---|---|---|
| Total (number) | 3461 | 64 |
| By risk factors (number) | | |
| Excessive dentistry | 269 | 12 |
| Periodontal disease | 39 | 17 |
| Alfalfa-exclusive diet | 79 | 12 |
| Endocrine-related disorder | 676 | 42 |
| EMS | 135 | |
| Cushing's disease | 59 | |
| Laminitis | 577 | |
| External/behavioral symptoms | 40 | 7 |
| Average age (years) | 9.3 | 12.6 |

ing Arabians. Geldings accounted for 45% of the horses, with mares accounting for another 35%.

In terms of the prevalence of our hypothesized risk factors, in the entire sample, there were 269 cases of excessive dentistry, 39 with periodontal disease, 79 on alfalfa-exclusive diets, and 676 with an endocrine-related disorder. Of the horses with endocrine-related disorders, 577 had laminits, 135 had EMS, and 59 had Cushing's disease. There were 40 cases that exhibited external or behavioral symptoms that were hypothesized manifestations of EORTH.

The outcome was defined by the coincidence of hypercementosis, incisor/tooth extraction, and resorptive/resorption syndrome; 248 horses had some mention of one of these, 174 had mention of two, 64 horses had all three and were coded for the statistical analysis as having EOTRH.

Table 2 displays the characteristics of the sample described above for the entire sample as well as for those coded as having the outcome.

We present the results of our statistical analyses in Table 3. The table consists of three columns, the first of which contains the variable with our hypothesized risk factors listed first. The columns labeled (1) and (2) present two models predicting EOTRH from the risk factors. In model (1), disorders are aggregated, whereas in model (2) we separately estimate the effects of EMS, Cushing's disease, and laminitis. For each model, we present the exponentiated logistic regression coefficients, or odds-ratios, and their robust standard errors (in parentheses).

When reading Table 3, keep in mind the following: the odds ratios act as measures of the strength or magnitude of the relationship between the predictor and outcome variables, interpretable as multipliers of the odds of the outcome occurring when a risk factor is present. The standard errors provide a sort of "on-average" margin for sampling error. We used one-tailed $P$ values to test our hypotheses because each posits a directional (ie, positive) relationship between predictor and outcome. Significance levels are indicated in the table by asterisks next to the odds ratios. This choice of $\alpha$ implies a conventionally accepted 5% risk of "type I" error, that is, of falsely inferring that a risk factor relates to an outcome.

**Table 3. Predicting EOTRH: Logistic Regression Odds Ratios for Hypothesized Risk Factors**

| | Dependent Variable (DV) = Coded as EOTRH | |
|---|---|---|
| Predictor | (1) | (2) |
| Risk factors | | |
| Excessive dentistry | 5.17‡ (0.79) | 4.83‡ (0.70) |
| Periodontal disease | 5.24‡ (2.53) | 6.05‡ (2.86) |
| Low-mastication feed | 2.01* (0.69) | 2.20* (0.81) |
| Endocrine disorder | 1.55† (0.22) | |
| EMS | | 1.98* (0.66) |
| Cushing's disease | | 2.30† (0.58) |
| Laminitis | | 1.073 (.143) |
| Manifestations | | |
| Behavioral symptoms | 3.57† (1.30) | 3.57† (1.30) |
| Controls | | |
| Breed | | |
| Arab | 1.28~(0.15) | 1.28~(0.15) |
| Thoroughbred | 0.85 (0.14) | 0.85 (0.14) |
| Sex | | |
| Mare | 0.61~ (0.10) | 0.69~ (0.11) |
| Gelding | 0.67~(0.10) | 0.77~(0.11) |
| Age | 0.99 (0.6) | 0.99 (0.6) |
| Model-fit $\chi^2$ | 199‡ | 199‡ |
| Pseudo-$R^2$ | .1426 | .1426 |

Robust standard errors are given in parentheses.
Notes: $N$ = 3461 horses (13,707 total visits). Odds ratios are obtained by exponentiating the logistic regression coefficients. Standard errors are adjusted for non-independence caused by repeated observations per horse.
Significance levels: *<0.05;†<0.01; ‡<0.001.

In Table 3, rows 1 through 4 contain the results for our hypothesized risk factors. As an overview, all of our risk factors have statistically significant coefficients, all in the predicted direction. EOTRH thus appears to have a number of antecedents, so let us go through these results in more detail. H1, that excessive dentistry increases the risk of obtaining EOTRH, is strongly supported. An indication of prior treatment by a lay dentist or a procedure such as incisor reduction make a horse nearly 5 times more likely to subsequent development of hypercementosis/resorptive syndrome. H2 is likewise supported, with prior periodontal disease also increasing the chances of EOTRH by a factor of 5. Horses on feed with low mastication time, operationalized in this study as a diet of alfalfa with no time on pasture, are twice as likely to develop EOTRH, supporting Hypothesis 3.

We turn now to endocrine disorders as risk factors for EOTRH. Looking first at model (1) in which we use an aggregate measure, we find, as hypothesized in H4, that they are positively related to EOTRH. In aggregate, having an endocrine disorder increases the odds of EOTRH by >50%. In (2), we obtained separate estimates for each of the endocrine disorders, revealing that EMS is most strongly related to EOTRH, with an odds ratio of 2.5. Cushing's disease is also a significant predictor, nearly doubling the odds of the outcome. The coefficient for laminitis, when taken separately from the primary endocrine disorders, was close to unity and not statistically significant.

Moving beyond the tests of our hypotheses, we can remark on the other variables that we included as manifestations of EOTRH, or as controls. The results in Table 3 indicate that the external and behavioral symptoms are significant correlates of EOTRH. External signs, such as excess salivation, and behaviors such as mouthing a water bucket, are symptomatic of EOTRH. We note, without remark, that Arabians are at greater risk than other breeds and that mares and geldings are less prone than stallions. Age is not a significant predictor in our study. This is perhaps somewhat surprising but tells us that it is not maturation in and of itself that puts a horse at risk of EOTRH. Rather, it is the other risk factors that attend to aging.

The follow-up clinical exams and owner survey served to validate the statistical results just presented, in terms of clinical findings, signs and symptoms, and histories. There were many common findings involving the clinical exams for the selected cases: (1) periodontal disease, including petecchiation of the gingiva over the teeth, draining tracts, purulent discharge, inflamed gingiva, loose teeth, enlarged, bulbous teeth, pain elicited when tapping affected teeth, and a foul odor present, (2) signs of PPID including a long haircoat, and (3) body condition and signs of EMS, including regional adiposity.

The follow-up questionnaire given to owners also revealed a series of similar clinical signs and symptoms for the subsample of horses coded as EOTRH: (1) inappetance and slow eating, (2) salivation/drooling and foaming of the mouth, (3) exhibiting a smiling appearance at rest and when riding whereby the lips are pulled back, (4) evidence of previous periodontal disease and the exhibition of a painful response when the teeth were tapped, (5) standing at the water tank, rinsing the mouth, or holding the mouth in the water tank (one owner reported that the horse's muzzle was always wet, and one owner reported that the horse's tongue was always held between the teeth), 6) late shedding of the haircoat and the presence of an unusually long haircoat.

Finally, a review of the histories of the horses selected for follow-up converged on these points: (1) excessive reduction of the incisor teeth and/or cheek teeth, (2) lack of grazing, (3) the feeding of primarily alfalfa hay, and, (4) the history of laminitis.

## 4. Discussion

History of excessive dentistry was nearly 5-fold higher when predicting the presence of EOTRH. Dr Carsten Staszyk in 2010 hypothesized that mechanical stress within the periodontal ligament may be the initiating factor of EORTH.

Regarding trauma, as in excessive dentistry, cementoblasts are present in the periodontal ligament.[15] Cementum can respond to harmful events quickly after harmful stimuli by further rapid deposition of cementum. Cementum has a high percentage of mineral present (approximately 65%). Within the mineral content, a large portion is calcium hydroxyapatite.[16–18] The calcium content of alfalfa is disproportionately high when compared with phosphorus. Could feeding straight alfalfa along with excessive dentistry be compounding risk factors?

The prevalence of periodontal disease was shown to be a supporting piece of evidence when predicting a positive risk factor for EOTRH, as previous research has indicated. Horses with prior periodontal disease increased risk by factor of 5.

As mentioned in the Results, horses fed alfalfa without pasture or grazing are twice as likely to have EOTRH. Hypervitaminosis A has been listed as a possible etiology of EOTRH.[5] Alfalfa and other legume hay have a high percentage of calcium (1.2–1.8%) compared with grasses that tend to be relatively low in calcium (0.3–0.7%). Phosphorus tends to be low in most forage (0.23–0.33%). Legume hay is also a source of provitamin A (beta-carotene), which is metabolized to vitamin A in horses within the small intestine.[19] In addition to the lack of chewing time and elevation of the horse's head while chewing, alfalfa requires much less chewing time. As mentioned earlier, the lack of chewing time and difference in elevation of the head will decrease the amount, time, and path of bathing the teeth and gums with saliva.

Although laminitis was not found to be a significant risk factor for EOTRH in our sample, further research is warranted. The associated laminitis that has been found to be as a result of horses having the disease of EMS may have similar mechanisms of producing EOTRH. It has been found in horses with EMS-induced laminitis that the insulin-induced lesions showed cellular changes and stretching elongation of the secondary epidermal lamellae.[11,12,20] According to another author, levels of matrix metalloprotease 9 were increased 48 hours after the corresponding neutrophil infiltration of the lamellae.[21] In addition, thrombosis, hypertension, catabolism of structural laminar proteins, vasoconstriction, and dysregulation of laminar cell growth have been listed.[12] It would be interesting to compare in further research the effect of high insulin levels and hyperglycemia on the periodontal ligament and Sharpey fibers to see if stretching and cellular changes would also occur with those structures. As mentioned before, it is the author's opinion that there may be a correlation as to the level of cortizol seen in small-animal joints and stretching of the periodontal ligaments as well.

The existing treatments for EOTRH include removal of affected teeth with regional anesthesia and standing sedation,[22,23] rinsing with 0.12% chlorhexidine, and treatment with trimethoprim sulfa 24 mg/kg q12 hours orally for 28 days[14] and splinting to prevent drifting of adjacent teeth after removal of affected incisors.[a] This disease is very painful for the horse, and the treatment regimen is very difficult for the patient to endure. The follow-up after removing teeth will be continuous to make sure the mouth stays in balance with occlusion.

The equine veterinarian must consider the existing risk factors when examining the horse and taking the history. These factors may be helpful when managing the prevention of the disease of EOTRH.

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[a]Personal communication from Dr Tom Johnson, Advanced Equine Dentistry, Grass Lake, Michigan.
[b]Prascend®, Boehringer Ingelheim Vetmedica GmbH, Binger Str. 173, 55216 Ingelheim, Germany.