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Post mortem survey of peripheral dental caries in 510 Swedish horses

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Summary

Reasons for performing study: **Peripheral caries (PC) of equine teeth is a poorly described disorder that can cause serious clinical problems if it progresses.**

Objectives: **To assess the prevalence, sites and severity of PC in a population of Swedish horses.**

Methods: **A *post mortem* study of 510 equine skulls was performed in 2 Swedish equine abattoirs.**

Results: **PC only affected the cheek teeth (CT) and was present in 6.1% (31/510) of skulls. It affected mainly the peripheral cementum, and 87% of PC in the 29 affected mature horses occurred in the 3 caudal CT (Triadan 09-11). Concurrent infundibular caries involving most maxillary CT (mean 9.7/skull) was present in 32% of skulls affected with PC. Trotting horses (mean age 8.1 years) believed to be on a high concentrate and silage diet were preferentially affected with PC in this population. Food was usually tightly adherent to the PC lesions and this feature may have promoted the progression of the disease. Significantly increased levels of diastemata were present in PC-affected horses, and periodontal disease was present in areas adjacent to some PC lesions.**

Conclusions: **PC is a relatively common disorder of horses under certain management conditions that can progress to cause serious dental disorders, especially if concurrent, widespread infundibular caries is present.**

Potential relevance: **Equine clinicians should be aware of this significant dental disorder and research into its aetiopathogenesis, possible prevention and treatment are required.**

Introduction

Dental caries is defined as a bacterial disease of the calcified dental tissues, characterised by demineralisation of the inorganic and destruction of the organic dental structures (Soames and Southam 2005). Peripheral caries (PC), which usually affects the cheek teeth (CT), has been recorded briefly in horses (Baker 1979; Easley 1991; Dacre 2006; Dixon *et al.* 2010), with short descriptions of its pathology given by Dacre (2005) and du Toit *et al.* (2008a). Although sometimes termed peripheral *cemental* caries, progression of this disorder leads to caries of the underlying enamel and dentine (du Toit *et al.* 2008a) and so PC is a more suitable term for this disorder (Dixon *et al.* 2010). The anatomical location of caries on the periphery of affected CT differentiates PC from the well described disorder of infundibular caries that affects maxillary CT only (Colyer 1906; Honma *et al.* 1962; Baker 1974; Kilic *et al.* 1997a; Brigham and Duncanson 2000; du Toit *et al.* 2008a). Caries (of all the calcified dental tissues) can also occur in equine teeth secondary to dental fractures (Dacre *et al.* 2007), apical infections (Dacre *et al.* 2008a,b), and in incisors and canine teeth affected with equine odontoclastic tooth resorption and hypercementosis (EOTRH) syndrome (Staszyk *et al.* 2008).

In addition to the initial loss of cementum around the periphery of CT, destruction of peripheral cementum can also occur deep in cemental infoldings, thus contributing to increased occlusal wear in PC-affected CT (Dacre 2005). PC may also initiate the development of CT diastema by causing destruction of interproximal calcified tissues, and also instigates periodontal disease by damaging the normal tight junction between gingiva and peripheral cementum at the gingival margin (Dacre 2005). Destruction of peripheral cementum also allows the development of protruding areas of brittle enamel on the occlusal surface that may be prone to fracture (Dacre 2005). PC is anecdotally stated to preferentially affect the more caudally located CT in horses (Dacre 2006), which can be difficult to fully examine clinically, and therefore this disorder may be clinically underdiagnosed. Severe, widespread PC affecting groups of horses has been associated with feeding silage with high levels of added acid, and also with feeding high levels of processed maize foodstuffs (Dixon *et al.* 2010).

Despite the above reports, little objective information is available on the prevalence or degree of equine PC in different horse populations. The purpose of this study was to describe the prevalence and gross appearance of PC at *post mortem* examination in a population of horses examined in 2 Swedish horse abattoirs.

Materials and methods

Between December 2003 and April 2005, the skulls of 510 horses, that had passed health examinations prior to slaughter, were examined *post mortem* in 2 Swedish equine abattoirs. The abattoir records of each case included details of breed, gender and age. Information on the reason for slaughter and prior dental history were obtained by direct and telephone interviews with horse

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TABLE 1: Grading of equine dental caries

Zero degree: No evidence of caries on a macroscopic level, but can include central infundibular cemental hypoplasia
First degree: Caries only affects cementum – subdivided into:
Class 1 Small, pitting superficial focal lesions
Class 2 Extensive destruction and loss of cementum
Second degree: Caries extends into adjacent enamel
Third degree: Caries extends into adjacent enamel and dentine
Fourth degree: Advanced caries affects the integrity of the tooth, predisposing to apical abscess or dental fracture
Fifth degree: Extensive caries results in tooth loss

TABLE 2: Prevalence and severity of peripheral caries (PC) lesions at individual Triadan positions of 367 affected permanent cheek teeth (CT) in 29 mature horses

Teeth affected	Degree of PC	06	07	08	09	10	11
Maxillary CT	1st degree class 1	4	1	14	14	1	14
	1st degree class 2	0	3	5	35	56	43
	2nd degree	0	0	0	0	0	0
	3rd degree	0	0	0	0	0	0
	4th degree	0	0	1	0	0	0
Mandibular CT	1st degree class 1	1	0	8	18	7	8
	1st degree class 2	0	2	6	26	48	48
	2nd degree	0	0	0	0	0	0
	3rd degree	0	0	0	0	0	0
	4th degree	0	0	2	2	0	0
Total		5	6	36	95	112	113

owners/trainers for 489 of the 510 cases. After being subjected to euthanasia by stunning and exsanguination, the heads were removed and the mandibles disarticulated to allow a complete visual examination of the oral cavity, with particular emphasis placed on documenting all instances of dental caries.

In this study, PC was classified using an adaptation of a human dental caries classification by Honma *et al.* (1962) for grading infundibular caries, as later modified by Dacre (2005) to also allow its use to classify equine PCs (Table 1).

Results

The skulls of 510 horses (303 female and 207 male), mean age 12.7 (range 0.5–31) years, including 274 (53.7%) Warmblood trotters, 86 Swedish half-breds, 58 North Swedish horses, 24 ponies and 68 horses of 20 other breeds were examined. The reason for slaughter included: musculoskeletal problems (n = 162); poor racing performance or end of racing career (n = 122); old age (n = 68); lack of time/interest by owners (n = 53); behavioural problems (n = 23); infertility (n = 20); miscellaneous and multiple problems (n = 30); dental-related or perceived dental-related problems (n = 11). No information was available in 21 cases. Regular dental treatment was provided for 293 (60%) of horses, but only on an annual or more frequent basis in 112 (23%) and 6 owners stated this dental 'care' was given by farriers and 2 owners performed their own dental treatments.

Thirty-one skulls (6.1%) from 18 male and 13 female horses, mean age 8.1 years (range 1.5–15 years), including 29 mature horses and 2 immature horses (age 1.5 and 2.5 years) with incomplete dentition, had some CT affected with PC. No caries of incisors, canine or wolf teeth was found in any horse. The number of CT affected with PC varied from 7 to 23 (mean 11.8) per affected horse. Table 2 includes data on the 29 affected mature horses only. The 1.5-year-old horse had caries of all 12 deciduous CT (premolars) while in contrast the 2.5-year-old horse had caries of all its 8 permanent CT. The most affected CT had 1st degree (class 1 or 2) caries while more severe degrees of PC were uncommon (Table 2).

Food was usually firmly adhered to the sides of PC-affected teeth (Fig 1) and substantial brushing and rinsing with water was needed to remove it. In contrast, food was readily washed off unaffected teeth. Examples of (washed) teeth with 1st degree PC are shown in Figures 2 and 3.

Data in Table 2 show that 87% (320) of the 367 PC-affected teeth in the 29 affected mature horses were in the Triadan 09-11 positions, with only 13% (47) located in the Triadan 06-08 positions. In particular, 97% (225 of 232) of the 2 most caudally located CT (Triadan 10 and 11) of affected horses had PC, while just 4.7% (11 of 232) of the Triadan 06 or 07 CT were affected in these horses. This caudal distribution of PC is very apparent in the specimens shown in Figures 1, 2 and 5. Table 2 also shows that more severe (in particular 1st degree, class 2) caries was 13.6-fold more common in the 3 caudal, as compared to the 3 rostral CT (Figs 2 and 7).

Dental fractures (4th degree caries) were found in 5 CT in 3 of the 31 PC-affected skulls (9.7%) (Fig 5), including in 4 mandibular and one maxillary CT. All 5 fractures were on the buccal aspect of CT and all ran through a single pulp horn, i.e. 1st or 2nd pulp horns, using the revised equine pulp numbering system of du Toit *et al.* (2008b), with fissure fractures extending to the adjacent ipsilateral pulp horn also present in some CT (Fig 5). No complete fracture planes ran through sites of normal anatomical weaknesses, e.g. sagittally through both the 1st and 2nd pulp horns, or through both infundibula, which are common fracture patterns in idiopathic fractures of equine CT (Dacre *et al.* 2007). Idiopathic fractures (including lateral 'slab' and midline sagittal fractures) were present in the non-PC-affected horses with 47 idiopathic CT fractures present in 43 of these 479 horses (10.9% prevalence) that did not significantly differ (P = 0.06; Fisher's exact probability test) from the prevalence in PC-affected horses.

Ten (30%) of the 31 horses with PC also had infundibular caries that involved multiple maxillary CT in all 10 horses, with a total of 97 CT concurrently affected (mean 9.7 affected CT/horse) (Table 3; Fig 6). The horses without PC had a prevalence of infundibular caries of 16% (76/479) that was significantly lower (P = 0.02; χ^2_1 = 5.58, χ^2 test) than that of PC-affected horses. Additionally, these 76 horses without PC had a total of 214 CT affected (mean affected 2.8 teeth/horse), with 83.6% of affected CT in the maxillary 09 position. In PC-affected horses, more severe (2nd and 3rd degree) infundibular caries was 3-fold more common in the caudal 3 CT (Triadan 09-11 positions) than in the rostral (Triadan 06-08) 3 CT. As noted, no midline sagittal fractures were found in CT with infundibular caries, despite extensive caries of both infundibulae being present in many of these CT (Fig 7). The extension of PC into peripheral enamel (2nd degree caries) was only present in CT with concurrent infundibular caries and the sites of enamel destruction at the rostral and caudal margins of CT, which was adjacent to areas of 3rd degree infundibular caries (Figs 6, 7) strongly indicated that an extension of infundibular caries, rather than of PC caused the enamel destruction in these maxillary CT.

There was a significantly higher prevalence of diastemata in horses with PC (64.5%; 20/31) compared to horses without PC (45.7%; 218/479) (P = 0.04; χ^2_1 = 4.23) with the more caudal interdental spaces most commonly involved in both groups of horses.

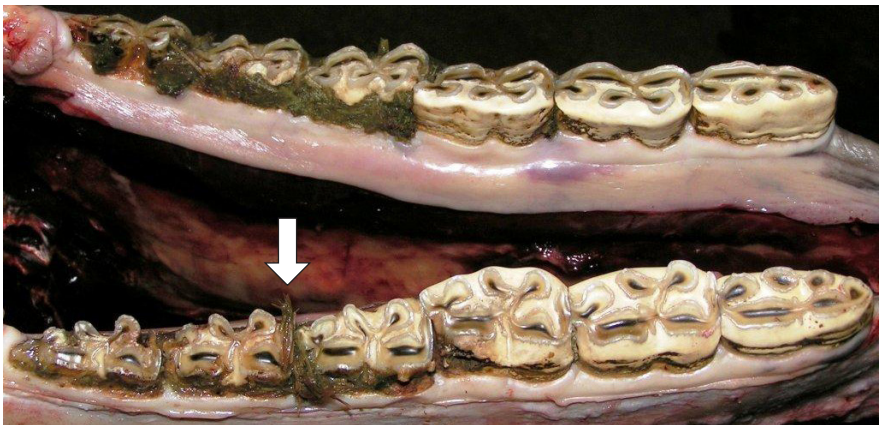

Fig 1: Mandible of a 5-year-old Warmblood trotter affected with peripheral caries, showing food bilaterally attached to the periphery of the caudal 3 cheek teeth (Triadan 09–11), with the rostral 3 cheek teeth (Triadan 06-08) largely unaffected by peripheral caries. Diastemata with periodontal food pocketing are present, including between 409 and 410 (arrow).

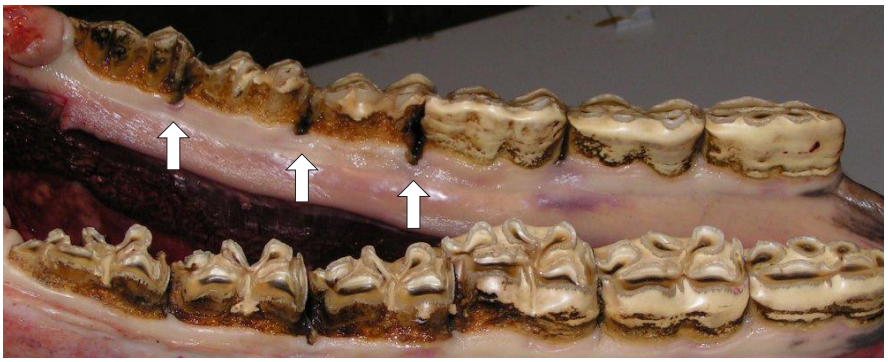

Fig 2: Washed mandible of 5-year-old Warmblood trotter showing bilateral, 1st degree, class 2 peripheral caries of the caudal 3 cheek teeth, with marginal involvement of the caudo-lateral aspect of 408. Diastemata are also present between the caudal cheek teeth, most obviously in the left hemimandible (arrows).

Fig 3: Close-up view of mandibular cheek teeth of a 1.5-year-old Warmblood trotter that are bilaterally affected with 1st degree, class 1 peripheral caries. In addition, note the irregular, slightly erythematous gingival margin adjacent to the carious cementum.

Buccal mucosal lacerations, caused by sharp enamel points (all opposite maxillary 09s-11s), were present in 93.5% (28/31) of horses affected by PC (bilaterally in 22, unilaterally in 6) and dental-related lingual ulcerations were present in 2 heads. An 86.6% prevalence of buccal ulceration was found in the 479 heads without PC, which was slightly lower than the prevalence of buccal ulceration in PC-affected skulls (P = 0.02; Fisher's exact probability test). Low-grade gingivitis was commonly present adjacent to areas of PC (Figs 1, 3, 4), but only one horse had deep periodontal food pocketing, not associated with a diastema, adjacent to teeth affected with PC.

A statistically significant difference in the prevalence of PC was found between breeds with 28 of the 31 PC-affected cases being Swedish trotters (10.2% prevalence in the 274 horses of this breed) while a 1.3% prevalence (3/236) were found among the other 236 horses of other breeds ($P<0.001$, $\chi^2_1 = 16.25$). One of these latter 3 horses (a Swedish half-breed horse) lived in a trotting stable on the same diet as the trotting horses. No management information was available on the other 2 non-trotter horses affected with PC.

Discussion

No incisors, canine or wolf teeth (Triadan 05) were affected with PC in this study. Horses affected with PC had multiple CT involved (mean 12.3 affected CT/horse) and the more caudally located CT were more commonly affected by PC, with 87% of affected teeth situated in Triadan positions 09–11 and only 13% in the 06–08

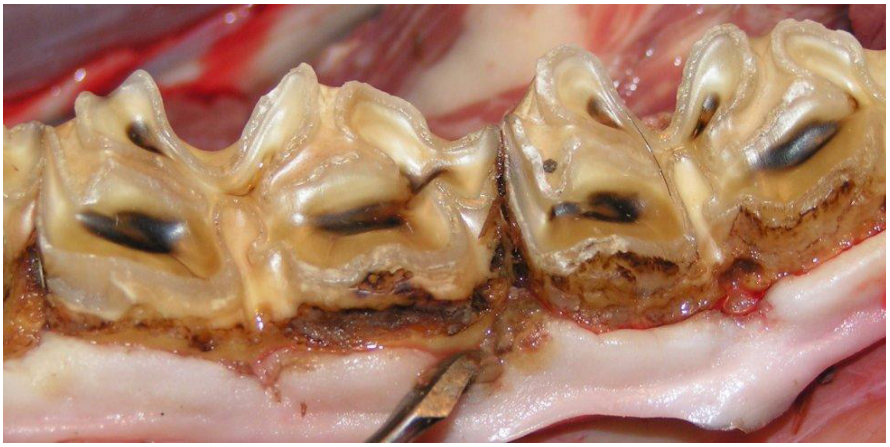

Fig 4: The buccal (lateral) aspect of 2 mandibular cheek teeth (410 left; 409 right) of an 11-year-old Warmblood trotter affected with 1st degree, class 2, peripheral caries showing disruption of the gingival margin, especially adjadent to the interdental space. A periodontal pocket is apparent where the gingiva has been retracted.

Fig 5: The mandibular cheek teeth on left (410 of 13-year-old Warmblood trotter) has a fracture on its buccal aspect involving the 1st pulp horn (arrow) with a fissure fracture extending into the 2nd pulp horn, while the tooth on the right (409) has a fracture of the 2nd pulp horn (arrow), with a fissure fracture extending into the 1st pulp horn. The tooth on left has 1st degree, class 2 peripheral caries, with destruction of the underlying enamel also present at the fracture site.

positions (Table 1). The more caudal affected CT also had more severe PC than rostrally situated CT (Table 2). Combined, these findings indicate that the environment in the caudal aspect of the oral cavity (likely a low pH and perhaps abnormal bacterial proliferation) is more liable to induce PC in susceptible horses. As the equine salivary ducts drain into the rostral aspect of the oral cavity, decreased salivary pH buffering may be present in the caudal aspect of the oral cavity (C. Staszyk, personal communication).

Horses suffering from the classical form of infundibular caries usually have a low number of affected CT, and usually those in the Triadan 09 position (Baker 1974; Kilic *et al.* 1997b; Crabill and Schumacher 1998; Dixon *et al.* 2010; Fitzgibbons *et al*. 2010). Similarly, this study found that 83.6% of CT with infundibular caries in the non-PC-affected skulls were in the Triadan 09 position, with a mean of 2.8 affected CT per non-PC-affected horse. In contrast, the 10 PC-affected horses that had infundibular caries, had most of their maxillary CT (mean 9.7 CT per horse) affected with infundibular caries, indicating a major difference between these latter cases and the classical form of infundibular caries. The caudal distribution of infundibular caries, especially of more severe infundibular caries (Table 3), further supports that the caudal aspect of the oral cavity in the current PC-affected cases had a caries-inducing environment. In this study, where the mean age of all horses was 12.7 years, PC tended to affect younger horses (mean age 8.1 years). This finding is also in contrast to classical infundibular caries, which increases in prevalence in older horses (Honma *et al.* 1962; Baker 1974; Crabill and Schumacher 1998). However, this young age likely just reflects the at-risk population in this study, i.e. Swedish trotting horses that were subjected to euthanasia towards the end of their normal racing career or earlier, if racing poorly or if suffering intercurrent diseases.

Teeth affected with PC were consistently found to have food tightly attached to their periphery that could only be removed with difficulty. This finding may be associated with the irregular and porous nature of peripheral cementum affected by PC that allowed tight adherence of food, in contrast to the normal smooth surface of peripheral CT cementum (Fig 2). It is likely that such adherence of food to the periphery of teeth in the early stages of PC would propagate the disease by preventing the normal cleaning action of food movements during mastication and the pH buffering action of saliva on the teeth, likely allowing prolonged and higher levels of caries-inducing bacteria and food-derived acids to remain in direct contact with the periphery of affected teeth. However, this mechanism would not explain the widespread presence of infundibular caries concurrently present in the maxillary CT of 30% of PC-affected horses.

It was believed that a reduction in the protective (‘crack stopper’) effect of peripheral cementum on adjacent (brittle) enamel in some PC-affected teeth, may have contributed to the development of fractures, as the fractured enamel did not appear to be eroded by caries, but being unsupported by normal peripheral cementum, it may have fractured under the high pressures of normal equine mastication. However, there was no significant difference in prevalence of idiopathic CT fractures between PC-affected horses (9.7% had one or more fractured CT) and non-PC-affected horses (10.4% had idiopathic CT fractures). The pattern of a single (buccally situated) pulp involvement in the CT fracture plane (albeit with fissure fractures to adjacent buccally