Dimensions of Diastemata and Associated Periodontal Food Pockets in Donkey Cheek Teeth

A study of the dimensions of diastemata and associated periodontal food pockets in donkey cheek teeth

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Summary

Equine cheek teeth (CT) diastemata often cause deep periodontal food pocketing and are regarded as a painful dental disorders of equidae. This post mortem study examined 16 donkey skulls (mean age 32 years) containing 45 CT diastemata to define the type and dimensions of diastemata, and of the associated periodontal food pockets that occur with this disorder. These diastemata were found to more commonly involve mandibular (56%) than maxillary CT (44%), and 71% of these diastemata had adjacent intercurrent dental disorders that may be associated with the diastemata. Diastemata were defined as open (60%) or valve (40%) based on their gross appearance. This classification was confirmed to be accurate by measurements of diastemata dimensions that showed valve diastemata to have an occlusal to gingival width ratio of 0.4, in contrast to open diastemata where this ratio was 1.07. Food was impacted in 89% of diastemata and periodontal food pocketing was present adjacent to 76% of diastemata, more commonly on their lateral aspect (73% prevalence – mean periodontal pocket depth 4.04mm) than the medial aspect (47% prevalence – mean depth 2.38mm). The depth of periodontal pockets of diastemata was not associated with the height of the erupted crown.

Introduction

Diastema (pleural diastemata) is defined as the presence of a space between adjacent incisor or cheek teeth (CT) that should normally be in contact at the occlusal surface. Food often becomes entrapped in diastemata causing painful periodontal food pocketing [1]. Consequently, CT diastema is a major cause of dental pain and quidding in horses [1-3]. Such pathological diastemata should not to be confused with the normal physiological diastema present in equids between CT and incisors ('bars of the mouth'). Diastemata can be defined as open (same width throughout the depth of the diastema) or valve (narrower at the occlusal aspect) diastemata, with the latter causing most food entrapment and thus clinical problems[2].

Cheek teeth diastemata have recently been recognised in donkeys on routine dental examinations [4] but little information is available on their etiopathogenesis or clinical significance. More information is available concerning equine diastemata, but no studies appear to have investigated the morphological appearance of equine CT diastemata in detail. The aim of this study was to define the dimensions of donkey diastemata and adjacent periodontal pockets, and to determine the accuracy of defining diastemata as valve or open, utilising gross post mortem examinations of donkey skulls from the aged population at The Donkey Sanctuary, Sidmouth, UK.

Materials and Methods

Donkey skulls from 349 donkeys from The Donkey Sanctuary, Sidmouth, UK that died or were euthanised for reasons unrelated to the head were examined and dental disorders recorded on a dental chart. Age at death was determined from computerised records that estimate the age of donkeys on admission to the sanctuary based on owner information and incisor examination by experienced staff. Only a small percentage of donkeys had precise dates of birth. In these 349 donkeys examined the prevalence of dental disease was 93.4%[5] and the median estimated age was 31 years (range 6 – 52). Random skulls (16) were selected from donkeys which had diastemata (prevalence of 85%[5]) for this study and the median age of these 16 donkeys was 32 years (range 12 – 56 years) which was very similar to all donkeys

(349) examined for dental disorders. Diastemata were classed as open or valve diastemata based on macroscopic appearance as previously described [2,3,6].

The width of each diastema was measured on its lateral (buccal) and medial (lingual or palatal) aspect at both the occlusal surface (A) and gingival level (B). The depth of periodontal pockets (C) were measured on the lateral and medial aspects when present (Figure 1). The erupted crown height was also measured (D). All measurements were obtained using digital callipers (Knighton[a]).

Data was recorded on Excel® and statistics performed using R (R V2.3.1, R Foundation for Statistical Computing). A major difficulty in terms of any statistical analysis was that for 4/16 (25%) of the skulls only one diastema was found/observed, but there was up to 6 diastemata in the other skulls (Figure 2). This meant for some skulls there was non-independence between diastemata, suggesting a mixed-effect model approach [7], but the skulls with a solitary diastema precluded such analysis. The concern was any statistically significant results being unduly influenced by multiple teeth from the same skull, but in the skulls with multiple diastemata it was difficult to select one diastema. Therefore, we employed a "bootstrapping" [8] methodology for the statistical testing. One diastema per skull was selected at random, creating a sample of 16 diastemata, on which the various statistical procedures were performed. This sample creation and subsequent statistical testing was carried out 10,000 times in order to ensure generation of results that were robust in terms of which diastema had been selected. The results are reported as a percentage of the 10,000 iterations in which statistical differences (at the 5%) level were obtained. The greater the percentage, the greater the robustness of any results that indicate statistically significant differences or correlations.

A one-sample t test was used to determine whether the difference between lateral and medial aspects of each diastema at occlusal (A), gingival (B) and periodontal pocket level (C) was statistically different from 0. A Mann-Whitney test was performed to determine the ratio of occlusal to gingival margin width in open and valve diastema on the lateral and medial aspect, as the data was not normally distributed. The depth of periodontal pockets was compared in open and valve diastemata using a Mann-Whitney test. The height of erupted cheek tooth crown was correlated with the depth of the periodontal pocket depth using Spearman's rank correlation test. Statistical significance was assumed at $P < 0.05$.

Results

A total of 45 diastemata were present in these 16 skulls, with between 1 – 6 diastema per skull (Figure 2). Twenty diastemata (44%) were between maxillary CT and 25 (56%) were between mandibular CT. All 45 diastemata were associated with periodontal disease although the severity of periodontal disease was not graded. Periodontal pockets were observed in 34 (75.6%) diastemata. Thirty-two (71%) of the diastemata had identifiable intercurrent cheek teeth disorders that may have predisposed to the diastemata, including displaced (n = 20), absent teeth (n = 7), fractured teeth (n = 2) and focal overgrowths on cheek teeth (n = 3). Food was impacted in the interdental spaces in 40 diastemata (89%) (Figure 3), and no food was present in the other 5 diastemata (3 open and 2 valve diastemata) at the time of our examination.

Difference in lateral and medial parameters

The mean, median and ranges of all the diastema width occlusally (A) and at the gingival margin (B), and periodontal pocket depth (C) at the lateral and medial aspects are tabulated in table 1. The bootstrap analyses revealed that there were no significant differences ($P>0.05$) between the lateral and medial width of the diastema at either the occlusal surface or the gingival margin, with 99.7% and 99.0% of the 10,000 simulated samples, respectively.

Periodontal pocketing (measurement C; Figure 4) was present in 34/45 diastemata (76%) with 33 having pocketing on the lateral aspect and 16 on the medial aspect. From the bootstrap analysis there was a statistically significant difference ($P<0.05$) in the depth of the periodontal pocketing between lateral and medial aspect with a greater depth of pocketing associated with the lateral aspect of maxillary and mandibular cheek teeth diastemata in 92.3% of the simulated samples (Figure 5).

Validating identification of open and valve diastemata

Diastemata were defined as being open or valve based on gross observation. Open diastemata were defined as diastemata that had the occlusal width as wide, or wider than the width at the gingival margin. Valve diastemata were defined as diastemata that were narrower at the occlusal aspect than the gingival margin. Of these 45 diastemata examined in this study 27 were defined as open and 18 as valve diastemata.

There did not appear to be a particular pattern to the prevalence of open or valve diastemata in the various positions, although overall valve diastemata were more common, comprising 55% of maxillary diastemata and 64% of mandibular diastemata.

The bootstrap analyses revealed the difference between open and valve diastemata ratios laterally (1.11 and 0.42 respectively) and medially (1.03 and 0.37 respectively) were statistically significantly different ($P<0.05$) in 99.3% and 86.0% of the simulated samples, respectively.

Periodontal pocket depth

The depth of periodontal pockets in open and valve diastema were compared to ascertain if there was a correlation between type of diastema and depth of periodontal pocketing. There was a tendency towards deeper lateral periodontal pockets beside valve diastemata, but this was not reflected in the bootstrap analyses, where no difference statistically significant at the 5% level was observed for 99.2% of simulated samples, with a similar lack of difference present for the medial pockets (99.6%) (Figure 7).

Association of periodontal pocket depth to erupted crown height

There was no association between the crown height to periodontal pocket depth, either medially or laterally, with no statistically significant difference at the 5% level observed for 95.2% and 96.0% of simulated samples, respectively.

Discussion

Cheek teeth diastemata has been recognised as one of the most painful oral disorders of horses[2] and usually causes quidding but is seldom recognised by practitioners [9]. The prevalence of diastemata in the general equid population is unknown and it is important that veterinarians are trained to clinically recognised cheek teeth diastema as a cause of quidding [3,6,9]. Diastemata have been observed in 4.6% of 349 *referred* horses with cheek teeth dental disorders [9]. A post mortem study of 355 horse skulls found a prevalence of 3.7% [10], while a more recent post mortem study of 50 horses found a prevalence of 20% [11]. The sample of 16 skulls that were used in this study were obtained from donkeys in a larger post mortem study examining 349 donkey skulls and had a much higher prevalence of 85.1%[5]. However, the median age of this population was 32 years (range 12 – 56 years) compared to the study by Dixon *et al.* (1999)[9] where the median age was 7 (3-24). The study by Dixon *et al.* (1999)[9] also noted that diastemata occurred with equal frequency in maxillary and mandibular rows and that they were most commonly found between the 09s and 10s, but more recent studies have shown an increased prevalence of diastemata in the mandibular CT[2]. Similarly, diastemata were more prevalent in the mandibular row (63%) compared to the maxillary row (36%) in 349 donkeys examined in a larger study[5] and this was reflected in this sample of 16 donkeys skulls with more mandibular (56%) than maxillary (44%) diastemata.

Diastemata formation between equid cheek teeth is normally prevented by continued eruption of the caudally angulated rostral cheek teeth and rostrally angulated caudal cheek teeth [12]. Primary developmental diastemata can develop if there is inadequate rostro-caudal angulation or if the tooth buds develop too far apart relative to their supporting bones[2]. Secondary developmental diastemata can occur for a number of reasons, including beside cheek teeth adjacent to developmental displaced or supernumerary cheek teeth[2]. In equids the natural tapering of reserve crown towards their apices predisposes to the development of senile diastema as the animal ages and the erupted crown becomes narrower. The rostro-caudal angulation of the teeth (which also decreases with age) is then unable to compress the cheek teeth row adequately resulting in the development of senile diastemata [13]. Diastemata can also develop secondary to other acquired cheek teeth disorders such as acquired dental displacements or missing teeth. It can also occur secondary to tall overgrowths causing rostro-caudal cheek teeth drifting [2,3,6]. In the current study, 29% of the diastemata were not associated with intercurrent cheek teeth disorders and due to the high median age of donkeys (32 years) in this population, primary diastemata were most likely attributable to senile diastemata. A large proportion (44%) of these diastemata were associated with displaced teeth, some of which may have been acquired displacements as a consequence of severe periodontal disease associated with diastemata. Age related intercurrent dental disease may result in the development of multiple diastemata per donkey as was seen in 12 of the donkeys in this study.

The medial and lateral diastema width measurements taken in this study showed that each diastema was the same width on the medial and lateral aspect at both the occlusal and gingival margin. The classification of diastemata as open or closed was based on previous published definitions, with a triangular shaped defect recognised in valve diastema [6,14]. In this study the dimensions of diastemata were measured at the medial and lateral aspects of the occlusal surface and gingival margin after visual classification as being open or valve diastemata. The results from this study clearly illustrate a significant difference in the ratios of occlusal to gingival margin diastema width in open and valve diastemata. However the type of diastema did not appear to affect whether or not food was impacted as only 5 diastemata did not have food impacted of which 2 were valve and 3 open diastemata.

The study by Dixon *et al.* (1999)[9] showed that food pocketing was commonly present with CT diastemata with periodontal pockets of > 50mm deep recorded. Periodontal infection associated with deep periodontal food pocketing may occasionally progress to the mandible and maxillae causing osteomyelitis and oro-maxillary fistulas or sinusitis respectively [9]. Recently, direct anastomoses between blood vessels of the periodontal ligament and maxillary sinus have been demonstrated in the horse [15]. This provides a possible route of infection to the sinuses from periodontal disease. Periodontal pockets have also been measured in another equine study where depths up to 35mm was recorded in periodontal disease which was significantly greater than that recorded in non-diseased CT [16]. In this study periodontal disease was observed with all the diastemata and periodontal pocket depths of up to 8.47mm laterally and 7.1mm medially were recorded in 75.6% of the diastemata. It seems likely that the smaller periodontal pockets depths observed in this study could be due to the smaller relative size of the donkeys and the short reserve crowns of the old donkeys examined in this study. Periodontal pockets were more common on the lateral aspect and were predominantly deeper (mean = 4.63 +/- 0.37mm) than medial pockets (mean = 2.38 +/- 0.40mm). However, there was no significant difference between the periodontal pocket depths in open or valve diastemata. Periodontal pocket depth did not appear to be related to the height of the erupted crown of the adjacent cheek teeth.

In conclusion, this study has shown that the gross classification of diastemata into closed and valve types is accurate in older donkeys and in particular, has shown the presence of severe periodontal pocketing adjacent to most diastemata. This study highlights the need for this disorder to be recognised in donkeys, and further clinical studies will be required to determine the clinical significance of periodontal pockets associated with diastemata in donkeys.

Manufacturer's addresses

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Acknowledgements

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Table 1

Table 1: Mean, median and range of lateral and medial measurements A, B and C and measurement D (mm) of all diastemata (n = 45). A = occlusal diastema width; B = gingival margin diastema width; C = periodontal pocket depth; D = erupted crown length.

	Mean	**Median**	**Range**
A Lateral	1.98	1.86	0 – 5.74
A Medial	1.99	1.96	0 - 5.24
B Lateral	3.02	2.65	0.73 – 7.44
B Medial	3.20	2.98	0 – 7.41
C Lateral	4.04	3.98	0 – 8.47
C Medial	2.38	2.08	0 – 7.1
D Length	13.15	11.75	3.62 – 25.83

Figure legends

Figure 1: Illustration of the three measurements taken on the lateral and medial aspect of each diastema. A = diastema width at occlusal level; B = diastema width at gingival margin; C = periodontal pocket depth; D = length of erupted crown; CT = cheek tooth

Figure 2: Column graph illustrating the frequency of donkeys with the specific number of diastema per donkey observed in this study

Figure 3: Long fibres of food are transversely impacted in (A), a valve diastema that has a narrow opening on the occlusal surface and is wider apically, and (B) in an open diastema mandibular that has a wide opening occlusally. Note the presence of early-stage "senile excavation" ("smooth mouth") in the mandibular cheek teeth on the left (A) due to reduction in peripheral infolding at this more apical aspect of the crown.

Figure 4: After removal of impacted food, a large periodontal pocket is now obvious on the lateral aspect of a mandibular cheek tooth diastema. The periodontal pocket has spread rostrally and caudally to involve the lateral aspects of the two adjacent CT.

Figure 5: Boxplot of the bootstrap medians of periodontal pocket depths laterally (C-L) and medially (C-M) in mm

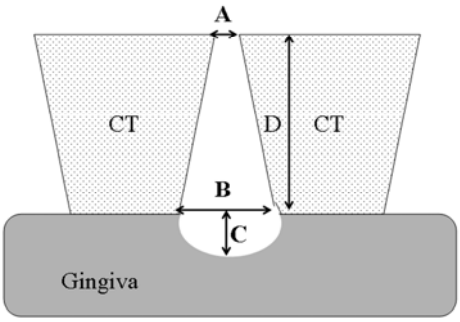
[a]Boxes represent interquartile range and horizontal lines represent medians

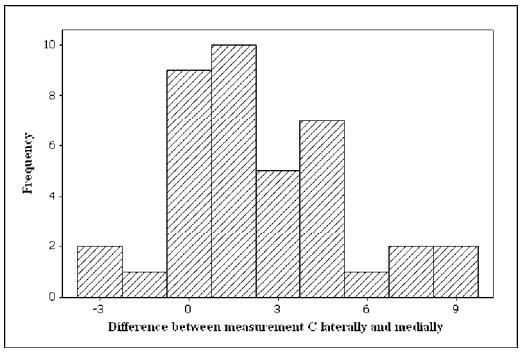
Figure 6: Boxplot of bootstrap medians of differences in ratios of occlusal width (A) to gingival margin (B) widths laterally (A-L/B-L) and medially (A-M/B-M) in open (O) and valve (V) diastemata[a]

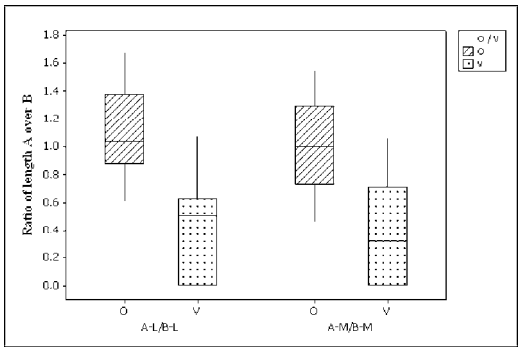
[a]Boxes represent interquartile range and horizontal lines represent medians

Figure 7: Boxplot of bootstrap medians of differences in periodontal pocket depth in open (O) and valve (V) diastemata on the lateral aspect (C-L) and medial aspect (C-M) of diastemata

[a]Boxes represent interquartile range and horizontal lines represent medians


A
CT
D
CT
B
C
Gingiva


Frequency
Difference between measurement C laterally and medially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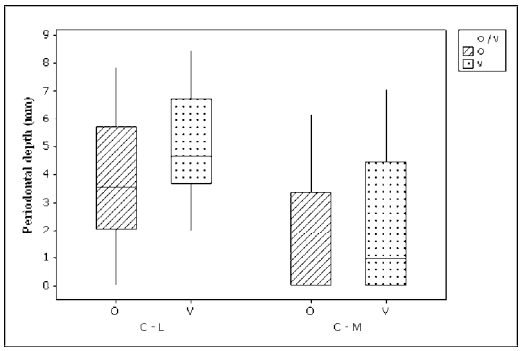
O / V
O
V
A-L/B-L
A-M/B-M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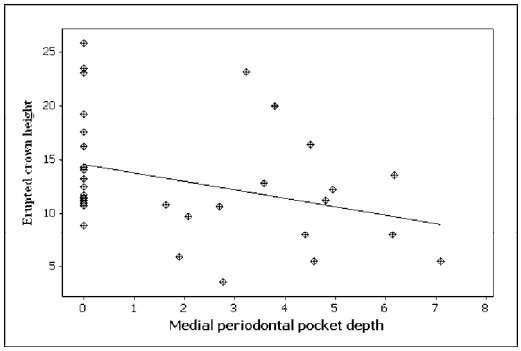
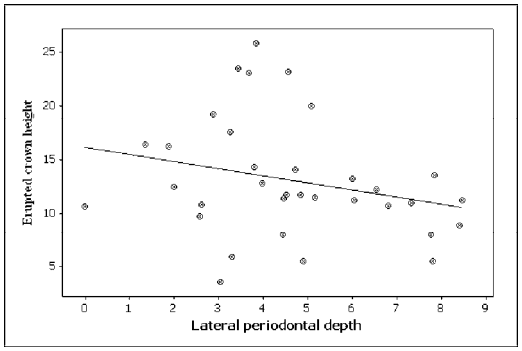
O / V
O
V
C - L
C - M


Erupted crown height
Medial periodontal pocket depth


Erupted crown height
Lateral periodontal depth