Scoring the Full Extent of Periodontal Disease in the Dog: Development of a Total Mouth Periodontal Score (TMPS) System

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Summary:

The development of a total mouth periodontal scoring system is described. This system uses methods to score the full extent of gingivitis and periodontitis of all tooth surfaces, weighted by size of teeth, and adjusted by size of dog. ***J Vet Dent 25 (3); @#$ - ^&*, 2008.***

Introduction

Periodontal disease scoring consists of measurements made on individual teeth. An adult dog with full dentition has 42 teeth, often with widely differing severity of periodontal disease in the same mouth at the same time. When multiple teeth are scored at a single time point, means of scores (gingival index or pocket depth, for example) of individual teeth have often been calculated and used in subsequent statistical analyses. The "mean mouth score" does not take into consideration the differences in size of teeth in dogs, and thus is not a reliable indicator of the extent of the insult to the body resulting from periodontal inflammation and infection. A previous study of the size of the buccal surfaces of the crowns of teeth demonstrated the extent of differences among teeth in dogs and cats and indicated that the simple "mean mouth score" system often used for plaque or calculus accumulation under-counts the largest (and often most severely affected) teeth.[1]

A periodontal disease score was reported in a study that investigated the association of periodontal disease with distant organ pathological changes. This score was based on combining measurements of plaque and calculus with disease parameters such as gingival inflammation and periodontal attachment loss. It also incorporated a simple weighting system to account for differences in size of teeth in the mouth of any one dog.[2] In a second study of the association between the extent of periodontal disease and the scores of microscopic changes in distant organs in dogs, a score described as the "periodontal disease burden" was used. It combined the measured circumference of the tooth and the periodontal pocket depth to estimate surface area of periodontal disease.[3] Both of these studies demonstrated a significant association between the periodontal disease score and microscopic changes in renal, hepatic, and cardiac tissue.

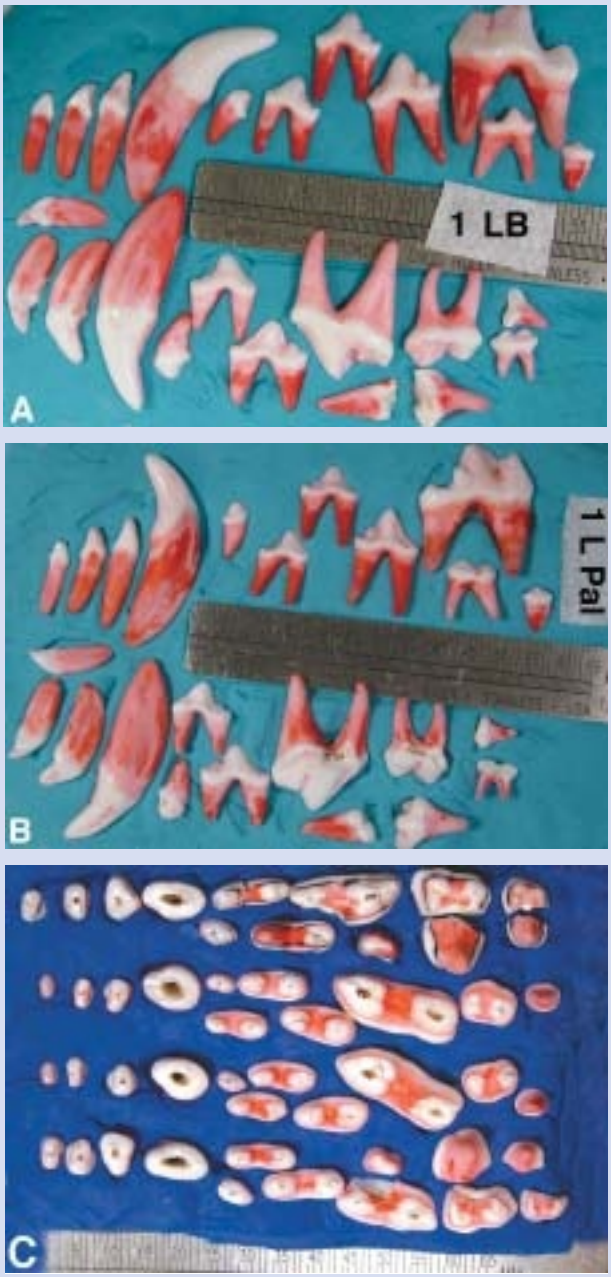
In the present paper, the concept of a mouth score that would reflect the contributions of periodontal diseases of all teeth is further developed. The purpose is to provide an accurate, repeatable means of measuring the extent of insult to the oral cavity resulting from periodontal disease, and to permit subsequent analysis of data sets to determine whether use of selected sites can be validated.

What to measure: inflammation, tissue loss, or both?

Periodontal disease results from accumulation of dental bacterial plaque on the surface of teeth, exacerbated by

Figure 1

Digital photographs of buccal (A), palatal (B), and apical (C) views of the stained teeth from the left side of one dog. To ensure tooth surface visibility, the teeth were pressed into modeling compound. Teeth are not necessarily in normal arch order to facilitate positioning on a rectangle of minimal size for photographic framing.



accumulation of mineralized dental calculus deposited from salivary fluid. Periodontal disease is usually separated into two clinical conditions, gingivitis and periodontitis.

Periodontitis (loss of periodontal ligament attachment and alveolar bone) occurs in irregular cycles. Although it is generally accepted that alveolar bone resorption does not occur without inflammation, some patients have periods of gingival inflammation during which no tissue loss occurs, while in other patients over the same period, or in the same patient over a different time period, attachment loss may occur.

Attempting to find a credible way of combining the two conditions (gingivitis [inflammation] and periodontitis [tissue loss]) into a single total mouth periodontal score (TMPS) was considered but abandoned because there are too many variables to permit calculation of inflammation:tissue-loss ratio necessary to generate a single TMPS. An inflammation score measures the extent of gingival inflammation present at that site on that day - there may be extensive inflammation present with no tissue loss. Conversely, there may be extensive attachment loss, but with no gingival inflammation present at the time of examination.

The gingival scoring systems most commonly used are based on a fixed semi-objective scale (typically 0-3 or 0-4). Loss of attachment is measured in mm with root length varying from 5-mm in some teeth to 15-mm or more in others, even in the same dog.

The TMPS system described here includes two independently scored and analyzed elements: Total Mouth Periodontal Score - Gingivitis (TMPS-G) and Total Mouth Periodontal Score – Periodontitis (TMPS-P). Separating TMPS-G from TMPS-P permits the application of a weighting criterion relevant for each score.

The TMPS-G is a comprehensive assessment of the extent of gingivitis in the mouth. The weighting factor for TMPS-G is the circumference of the cementoenamel junction (CEJ) at each site. The TMPS-P is a comprehensive assessment of periodontal tissue loss in the mouth. The weighting factor for TMPS-P is root surface area at each site.

Development of the weighting factors

The TMPS uses weighting factors to take into account the differences in size, shape, and number of roots of teeth in dogs. In an initial attempt to develop a weighting system for CEJ circumference and root surface area, radiographs of sectioned heads of two mesocephalic dogs were scanned to produce digital images, and the roots of teeth were electronically traced. Four problems became apparent: (1) separation of root from surrounding bone was not sufficiently clear around the full circumference of the teeth, even though they were radiographed in true parallel position (the heads were sectioned so that the long axis of the dental arch from canine to molar teeth was parallel to the plane of the radiograph); (2) roots of three-rooted teeth were not sufficiently separated at their attachments to the crown to permit the least visible root to be traced accurately; (3) the CEJ in the mid-buccal and mid-palatal areas was not clear. Examination of extracted teeth shows that the CEJ is not a straight mesial-distal line; and, (4) the arch of the incisor teeth is on a different plane from that of the canine-molar arch, and thus requires a separate radiograph.

Heads of 2 adult mesocephalic mid-sized dogs of unknown breed were obtained from a collection of heads used for practice of dental procedures. Both heads had all teeth present. The heads were defleshed and immersed in hot dilute hydrogen peroxide solution until the teeth could be readily removed with gentle application of extraction forceps. The teeth were rinsed and allowed to dry, then were immersed in 0.125 % eosin solution[a] for 15-minutes to stain the cementum. The teeth were then air-dried. For three-rooted teeth, the palatal root with its coronal cusp was separated from the rest of the tooth using a #699 dental bur.

The teeth were arranged on modeling compound[b] in as compact a manner as possible to show the surface of the roots of all teeth in each of the three views described below. Three digital photographic images of the teeth were made: buccal view of all teeth in each arch, including the buccal surface of the separated palatal roots of three-rooted teeth; palatal/lingual view of all teeth in each arch, including the palatal surface of the separated palatal roots of three-rooted teeth; and, apical view of the complete CEJ (Fig. 1). In order to obtain a view of the CEJ that was unobstructed in teeth with curved roots, a sufficient amount of the apical part of the roots of the teeth was removed with a #699 dental bur before an image was obtained of the apical view.

Measurement software[c] was used to scan and measure (mm, mm^2) each image. Images were calibrated individually using an endodontic ruler[d]. The line between buccal and palatal/lingual segments was made through the root canal of the tooth, on a line parallel to the arch at the location of that particular tooth. Separation into mesial or distal segments was made at the mid-furcation line. For the three-rooted teeth in the maxilla, the line separating root segments was made equidistant between the roots. The circumferences of the teeth were divided into scoring sites (Table 1). Surface area of each root (mm^2) was measured as seen two-dimensionally on the buccal or palatal/lingual views (Fig. 1). For the maxillary fourth premolar tooth, and first and second molar teeth, the palatal views of mesial and distal roots and the buccal views of the palatal roots were not measured – *i.e.* only those tooth surfaces with a gingival attachment were measured. The CEJ circumference (mm) was measured on the apical view (Fig. 1C).

The sum of the CEJ circumferences for each site (buccal or palatal) on each root, each tooth, each arch, each side, and each skull were recorded on a spreadsheet. The CEJ circumferences for each scoring site were then divided by the total of all CEJ circumferences for that skull to produce the gingival circumference weighting factor for each scoring site. The same process was completed using root surface area measurements to produce the root surface area weighting factor for each root site. The means of the weighting factors calculated in the two skulls were inserted into the TMPS scoring spreadsheet (Fig. 2).

Constructing the TMPS-G and TMPS-P scoring form

On a second spreadsheet, a template was constructed for insertion of the clinical data that would be collected from each site during a scoring episode. For each scoring site, the individual 0-3 Gingival Bleeding Index score for that site is multiplied by the CEJ circumference weighting factor for that site to produce a weighted

Figure 2

TMPS clinical scoring form.

TMPS Scoring Form

Patient information:

Date:_____

Scorer:_____

Height of Crown of one upper canine tooth (mid-bu ccal CEJ to tip of cusp in mm) =____

	Gingival Bleeding Index (0-3 scale)				Attachment Loss (maximum mm, CEJ to bottom of pocket)			
Site – Individual Root	R Buc	R Pal	L Buc	L Pal	R Buc	R Pal	L Buc	L Pal
Max I 1								
Max I 2								
Max I 3								
Canine								
Max P1								
Max P2 Mes								
Max P2 Dis								
Max P3 Mes								
Max P3 Dis								
Max P4 Mes		-		-		-		-
Max P4 Pal	-		-		-		-	
Max P4 Dis								
Max M1 Mes		-		-		-		-
Max M1 Pal	-		-		-		-	
Max M1 Dis		-		-		-		-
Max M2 Mes		-		-		-		-
Max M2 Pal	-		-		-		-	
Max M2 Dis		-		-		-		-
Mand I 1								
Mand I 2								
Mand I 3								
Canine								
Mand P1								
Mand P2 Mes								
Mand P2 Dis								
Mand P3 Mes								
Mand P3 Dis								
Mand P4 Mes								
Mand P4 Dis								
Mand M1 Mes								
Mand M1 Dis								
Mand M2 Mes								
Mand M2 Dis								
Mand M3								

**Always measure GBI first by gently inserting probe 1-2 mm and dragging along gingiva.

site score. The weighted site scores are summed to produce the total mouth gingivitis score (TMPS-G). The TMPS-G is a number between 0 and 3. It does not require body weight adjustment because it is a categorical score - the same 0-3 scale is used for each site regardless of the size of the tooth or size of the dog.

For each scoring site, the individual score for that site (maximum attachment loss in mm) is multiplied by the root area weighting factor for that site to produce a weighted periodontitis score. The weighted scores for all sites scored are summed to produce a raw total mouth periodontitis score (raw TMPS-P).

Dogs have great variability in body weight and tooth size (*e.g.* maxillary canine tooth). The variations of the mandibular first molar tooth height and the mandibular bone height have been studied relative to body weight.[4] Although there is a statistically

significant correlation between increasing body weight and increasing ratio of mandibular height to height of the first molar tooth (larger dogs have relatively smaller teeth than smaller dogs), the relationship is not linear (*e.g.* the difference is more apparent when toy and small dogs are compared with medium-sized dogs than when medium-sized dogs are compared with large-sized dogs) and is subject to variability comparing obese and non-obese patients. Therefore, the use of body weight as an adjustment factor when comparing the TMPS-P among dogs of different sizes is presumed to be not clinically or statistically reliable.

Crown height is available when scoring teeth and is specific to that individual dog. To determine whether crown height is reliably proportional to root height (and thus is likely to be an accurate adjustment factor for root surface area), intact maxillary canine teeth with closed apices from 18 dogs of various sizes and breeds were stained and photographed in lateral (buccal) view. On scanned images of the tooth, the mid-buccal point of the CEJ was identified on the image, and the straight-line root length from this point to the apex of the root was measured. The straight-line crown height from tip of cusp to the CEJ buccal mid-point was also measured. The mean crown height:root height ratio was 0.82 (SD ± 0.07). Based on the low standard deviation of this result, maxillary canine tooth crown height is considered to be sufficiently reliable to be used as the adjustment factor when comparing the TMPS-P of dogs of different sizes.

The TMPS-P clinical scoring form includes a space for recording maxillary crown height mid-buccal CEJ to crown tip) measured using an endodontic ruler (Fig. 2). This measurement is transferred to the electronic spreadsheet record for that scoring episode, and the size-adjusted TMPS-P is calculated automatically: the raw TMPS-P is divided by the crown height and multiplied by 10 to produce the "adjusted TMPS-P").

Confounding and complicating factors

Missing teeth would affect the result since TMPS-G and TMPS-P results are calculated from data collected from all teeth present in the mouth. Although missing teeth would most likely have been lost as a result of periodontal disease (or were extracted during treatment of periodontal disease), periodontal disease is not the only cause of absent teeth in dogs. The number of missing teeth in dogs increases with increasing age (as would be expected if periodontal disease is the primary cause of tooth loss); however, the number of missing teeth is also inversely proportional to body weight.[5] Direct trauma is also a common cause of tooth injury and sometimes tooth loss in dogs.

The options considered for missing teeth when calculating the TMPS-G and TMPS-P are: (1) Assign the score from the same tooth on the other side of the mouth. Periodontal disease is generally a symmetrical disease[5]; however, using the score of the opposite tooth would under-estimate the extent of attachment loss if the absent tooth was lost due to periodontal disease. Also, use of the opposite tooth is not possible when the same teeth in both right and left jaws are missing; (2) Score the missing tooth at the maximum possible score for that tooth. However, the gingival index score may not have been at the maximum when the tooth was lost. For TMPS-P, there is no predictable 'maximum score' for an individual tooth in an individual dog; (3) Eliminate the missing tooth from the TMPS-G and TMPS-P calculation. Eliminating only the numerator (the gingival score or loss of attachment measurement) would result in dilution of the TMPS-G and TMPS-P that might invalidate a study investigating periodontal disease in aged small breed dogs (*e.g.* an edentulous 12-year-old Yorkshire terrier included as a subject); (4) Eliminate the numerator (score) and denominator (weighting factor) for missing teeth, so that the TMPS-G and TMPS-P are calculated only from teeth that are present and scored. On the clinical score sheet and when the data are entered in the spreadsheet, the tooth is recorded as 'missing', and no gingival score or attachment loss measurement is recorded. Following completion of data entry, the spreadsheet calculates a true weighted score for the teeth that are present. This latter compensation for missing teeth is recommended for TMPS calculations.

Roots and CEJs of teeth are curved in three dimensions (buccal-palatal, mesial-distal, corono-apical) yet were measured in two dimensions. Inclusion of both palatal and buccal views permits the complete corono-apical curve of the CEJ to be included, but does not compensate for the buccal-palatal dimension. Since roots of teeth are generally ovoid, and the images measured in preparing the TMPS-P include the long-diameter (mesial-distal) view of the root, the error in under-measuring the items of interest is likely to be similar in all teeth. An exception to the 'generally ovoid' rule is the mandibular first molar tooth, which has a concavity on both roots extending to the furcation resulting in a slight under-weighting of root surface area of this tooth in the TMPS system.

Single score per root

Both the TMPS-G and TMPS-P over-score the extent of inflammation and attachment loss because they record the worst score for each root site. Alternatives considered were: recording the attachment loss at pre-set distances (*e.g.* in 2-mm increments from the mesial end). However, it would be cumbersome to use a ruler to ensure repeatable positioning of the probe; or, assign pre-set locations for scoring (*e.g.* mesial, mid-coronal, and distal). These methods introduce potential inter- and intra-observer differences and are more laborious compared with the recommended "highest score per site" system. Measuring attachment at pre-set locations or distances risks missing the deepest area of attachment loss and underscoring the extent of disease.

Recommended scoring techniques for the TMPS system

Gingival inflammation

Gingival Bleeding Index (see below) is recommended, as it provides a less subjective differentiation between each score criterion than use of purely visual indices.

One gingival score is recorded for the buccal and one score for the palatal/lingual surface of each root. For multi-rooted teeth, the scores are assessed for each root consecutively. Before inserting a probe into the gingival pocket over any root of a multi-rooted tooth, note whether there is spontaneous bleeding over any root (if yes, gingival score for that site is 3, and no further gingival observation is needed for that scoring site). If it is not clear where spontaneous bleeding is originating, use a gentle-applied water

spray to remove blood from the area, and re-observe the site.

For each non-bleeding root scoring site, first note visual assessment of gingival inflammation. Then note response to bleeding on probing by gently inserting a blunt periodontal probe 1-2 mm into the gingival pocket at the mesial end, and lightly moving it along to the distal end. Assign a single gingival bleeding index score for each root scoring site, based on the combined visual and response-to-probing observations.

Gingival Bleeding Index (GBI):

0 = No inflammation: normal gingiva.

1 = Mild inflammation: slight change in color, slight edema and no bleeding on probing.

2 = Moderate inflammation: redness, edema, glazing of surface. Bleeding on probing within 30-seconds.

3 = Severe inflammation: spontaneous bleeding or immediate bleeding on probing.

Record the GBI for that site on the scoring sheet.

Loss of periodontal attachment

In a study in which both TMPS-G and TMPS-P are recorded, measure loss of attachment after the gingival scoring for that site has been completed. If the CEJ is covered by gingiva, use a blunt instrument to gently retract the gingiva to observe the CEJ. If the CEJ area is covered by calculus, estimate the location of the CEJ based on the shape of the crown, identifying the dental bulge and the cervical region or 'neck' apical to it. For each root scoring site, use a blunt-tipped calibrated periodontal probe that is placed close to parallel to the long axis of the root to measure the deepest distance from the CEJ to the bottom of the pocket by gently "walking" the probe along the bottom of the pocket. Use of a calibrated-pressure probe is recommended. Simple "pocket depth" (height from bottom of pocket to gingival margin) is not measured. Record the attachment loss measurement for that site on the scoring chart.

Discussion

The significance of serum creatinine of 1.4 *versus* 4.1 is instantly recognizable to a veterinary clinician; serum creatinine concentration is a measure of the overall function of both kidneys. What is the periodontal health assessment equivalent? The TMPS was designed to provide an accurate, repeatable measure of the full extent of periodontal disease in a particular patient at a particular point in time. This assessment will permit analysis of correlations with measurements of whole-body and distant organ factors, and permit comparison of TMPS scores in the same patient over time. The first study using TMPS in dogs showed a correlation between TMPS scores and clinical pathological laboratory markers of systemic health.[6]

With the obvious exceptions of genetically deformed or traumatized teeth, clinical observation suggests that the shape of individual teeth in the mouth of one dog varies very little from the shape (and size relative to skull size) of the same tooth in the mouth of another dog… an extracted incisor tooth or maxillary first molar tooth can be readily identified by a veterinary dentist. The < 10 % standard deviation in the ratio of height of root to height of crown in canine teeth from 18 different dogs reported here supports the assumption that use of two dogs to develop the weighting factors is sufficient.

Collecting a full TMPS data set requires time-consuming oral examination by a trained scorer. Although there are data available to demonstrate that some teeth are more likely than others to develop severe loss of attachment in dogs,[1,7] and use of a convenient set of large and readily examined teeth is recommended for trials of rate of plaque and calculus accumulation,[8] there are no studies that validate selection of specific teeth or sets of teeth as representative of the full extent of periodontal disease in the mouth for correlation with systemic health. The TMPS system provides a means of conducting such validation studies in dogs by generating the data for subsequent analysis of sub-sets of teeth.

TMPS spreadsheet availability

The TMPS spreadsheet with weighting factors will be made available by C. E. Harvey on request. No computer skills other than data entry into a spreadsheet are required. Insert the scoring data into a blank copy of the electronic TMPS spread-sheet. The TMPS-G and TMPS-P will be automatically calculated. Save the file using a file name assigned to that dog and examination date. The TMPS spreadsheet is copyrighted by Colin Harvey and the University of Pennsylvania. It can be down-loaded from www.ceHarvey.com Permission to use it is granted provided that the source of the program is cited as TMPS© Colin Harvey and the University of Pennsylvania in any reports or publications that include use of TMPS.

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[a] Hema 3 solution 1, Fisher Diagnostics, Middletown, VA, US

[b] Play-Doh, Hasbro Inc, Pawtucket, RI, US

[c] SigmaScan Pro (version 5.0), Aspire Software International, Leesburg, VA, US

[d] MoyCo Union Broach Endo Ruler, STATE, US

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