Scoring Plaque and Calculus

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Scoring Plaque and Calculus

VOHC Function

Based on bacteria in plaque having been demonstrated to be the cause of gingival inflammation and periodontitis, and that dental calculus exacerbates bacterial plaque growth, VOHC awards its Accepted Seal to products that meet or exceed a pre-set standard of reduction in accumulation of plaque and/or calculus compared with a control group.

Therefore, accurate assessment of plaque and calculus is essential to the function and credibility of VOHC….
VOHC Protocol Requirement

Mean of 20% reduction in plaque and/or calculus accumulation in the two trials - must be at least 15% difference in each trial.

This is the same % reduction required to obtain American Dental Association Seal of Acceptance for plaque/gingivitis and tartar claims for e.g. tooth-pastes.

If the scoring system is questionable, the % reduction calculated from the scoring data is also questionable.
Scoring Plaque and Calculus

Purpose of this Presentation:

To generate interest on seeking ways to improve plaque and calculus scoring methodologies, so that VOHC’s Accepted List is determined by trial data produced using ‘best-practice’ scoring methods.
Scoring Plaque and Calculus

Items to be discussed:

Brief review of:

• History of plaque and calculus scoring.
• Challenges presented by dental scoring in dogs and cats.
• Recent progress in scoring methods

The Weak Link…….

Scoring Plaque and Calculus

A subjective visual observation is the most commonly used technique to evaluate used plaque and calculus. The steps are non-linear (ordinal or qualitative data) – a score of 4 does not equal twice a score of 2.

Result: Accuracy is questionable, and use of parametric statistical tests is questionable.
Turesky Plaque Index (1970) modification of the Quigley & Hein PI (962)

An attempt to collate location and extent, based on the understanding of pathophysiology of periodontal disease.

0 = No plaque
1 = Separate flecks of plaque at the cervical margin of the tooth.
2 = A thin continuous band of plaque (up to one mm) at the cervical margin of the tooth.
3 = Band of plaque wider than one mm but covering less than one-third of the crown.
4 = Plaque covering at least one-third but less than two thirds of the crown of the tooth.
5 = Plaque covering two-thirds or more of the crown of the tooth.
A small difference in % coverage may be scored as a major difference in score, and a major difference in % coverage can be scored as no difference in score.
Shape of Teeth

The challenge of assessing % coverage is exacerbated by the irregular shape of the teeth.

Where is the line separating 25% from 50%, and 50% from 75%?

Are these ‘lines’ repeatable inter-observer and intra-observer?

Shape is more regular in human teeth

Maxillary canine tooth of a dog

Mandibular first molar tooth of a dog
Relative Size of Teeth

Do teeth with very large differences in size merit equal consideration in determining the ‘mean mouth’ plaque score?

Human

Cat

Dog

Again, less difference in human teeth
## Relative Size of Teeth

Surface area of whole tooth as % of largest tooth, VOHC set only

<table>
<thead>
<tr>
<th>Tooth</th>
<th>I 2/3</th>
<th>C</th>
<th>P3/1</th>
<th>P4/2</th>
<th>M1</th>
<th>C</th>
<th>P3/1</th>
<th>P4/2</th>
<th>M1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog %</td>
<td>31</td>
<td>79</td>
<td>26</td>
<td>70</td>
<td>26</td>
<td>74</td>
<td>25</td>
<td>35</td>
<td>100</td>
</tr>
<tr>
<td>Cat %</td>
<td>-</td>
<td>100</td>
<td>41</td>
<td>72</td>
<td>-</td>
<td>72</td>
<td>34</td>
<td>57</td>
<td>74</td>
</tr>
<tr>
<td>Human %</td>
<td>61</td>
<td>96</td>
<td>75</td>
<td>72</td>
<td>97</td>
<td>83</td>
<td>74</td>
<td>66</td>
<td>100</td>
</tr>
</tbody>
</table>

P-085, Cat, DSH, left
Segmenting the Tooth Surface for Scoring

Horizontal and vertical lines have been used

If done strictly by calculation, there are massive differences in surface area of one segment vs. others

Harvey: Shape and size of teeth of dogs and cats: Relevance to studies of plaque and calculus accumulation. J Vet Dent 19; 186-195, 2002
Vertical Segmentation

Smallest Vertical Segment as % of Largest

<table>
<thead>
<tr>
<th></th>
<th>Largest vertical segment (%)</th>
<th>Smallest vertical segment (%)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog</td>
<td>9.3 (Middle Man M1)</td>
<td>1.3 (Mesial Max P3)</td>
<td>14%</td>
</tr>
<tr>
<td>Cat</td>
<td>8.1 (Middle Max P4)</td>
<td>1.6 (Distal Man P3)</td>
<td>20%</td>
</tr>
<tr>
<td>Human</td>
<td>5.5 (Middle Max C)</td>
<td>2.5 (Distal Man P1)</td>
<td>45%</td>
</tr>
</tbody>
</table>

VOHC Protocol Requirement:
Vertical segmentation no longer permitted.
## Horizontal Segmentation

Smallest horizontal segmentation area as % of largest area:

<table>
<thead>
<tr>
<th></th>
<th>Largest horizontal segment (%)</th>
<th>Smallest horizontal segment (%)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dog</strong></td>
<td>15.0 (Gingival Man M1)</td>
<td>1.7 (Occlusal Man P3)</td>
<td>11 %</td>
</tr>
<tr>
<td><strong>Cat</strong></td>
<td>14.2 (Gingival Max C)</td>
<td>2.4 (Occlusal Man P3)</td>
<td>17 %</td>
</tr>
<tr>
<td><strong>Human</strong></td>
<td>6.9 (Gin Max C, Max M1, Man M1)</td>
<td>4.2 (Gingival Max I3)</td>
<td>61 %</td>
</tr>
</tbody>
</table>

### Current VOHC Protocol Requirement

Horizontal segmentation can be used (and is recommended for canine teeth in cats), but only data from the gingival half can be used for analysis.
Segmenting the Tooth Surface

Using Natural Land-marks

Which still leaves the challenge of assessing irregular areas of plaque on teeth of irregular shape. ..
Thickness……

Plaque varies in thickness, with increasing thickness indicating increasingly anaerobic, pathogenic plaque. Extent of coverage is thus an overly simple assessment.

Some indices assess thickness on a 1-3 scale based on depth of disclosing solution color, recording only the deep of the deepest area.

A composite index is then calculated as coverage score multiplied by the thickness score. If maximum coverage score is 4, and maximum thickness score is 3, maximum composite score is 12.
Plaque ‘Thickness Score’ Causes Distortion

Thickness is recorded as the maximum depth of color anywhere on the tooth surface, but it is not uniform…..

Example shown: Extent score = 45% = Plaque Index is 2. Thickness score in area of deepest stain = 3. Plaque score = 2 x 3 = 6 (maximum score = 12).

But only 10% of plaque area is plaque thickness of 3, with e.g. 50% of thickness 2 and 40% of thickness 1. Recalculated to reflect thickness, score would be (2 x 0.1 x 3) = 0.6 plus (2 x 0.5 x 2) = 2 plus (2 x 0.4 x 1) = 0.8 = 3.4. Plaque Score = 3.4, about half of the score that would be recorded.
Consistent subjective scoring is not easy. Requires training and experience.

VOHC approves scorers, based on training, and inter-observer and intra-observer review.
If the scoring system is questionable, the % reduction calculated from the scoring data is also questionable.....
What Would Be Ideal for VOHC Use?

1. Quick, accurate, reliable/reproducible, producing quantitative data scoring extent of coverage and thickness of plaque or calculus, similar to a clinical lab chemical analyzer for measurement of glucose concentration in a blood sample.

2. Ideally not requiring anesthesia or sedation.

3. Suitable for both dogs and cats.

4. As automated as possible, to reduce variability.
   a. Technique is publicly available and cost-effective.
Apples: Apples and not Apples: **Oranges** comparison.

VOHC seeks proof of **sufficient** effectiveness.
What Are We Measuring? - Plaque

The primary interest in determining efficacy is extent of plaque at the gingival margin.

Is there value to knowing the extent/thickness of plaque on the e.g. coronal two-thirds of the crown?

The actual measurement should reflect the pathogenic potential of the plaque that is present.

Plaque rapidly adheres to the entire tooth surface (except to the extent that it is rubbed off by mechanical action during chewing). Is a method that assesses specific bacteriological properties inherently more valuable than an analysis that measures any material that is stained by a disclosing solution?
Calculus is not the cause of periodontal disease, but it exacerbates accumulation and maturation of the plaque biofilm. It is of interest because, unlike plaque, established calculus cannot be simply rubbed off the surface of the teeth – regular, sustained retardation can be considered to be more critical than plaque. If accumulation of calculus is slowed down, there will be a slow-down of accumulation and maturation of plaque.

The primary interest in determining efficacy is extent of calculus at the gingival margin or subgingivally, as it harbors the plaque biofilm in the area that results in gingivitis.
Digital Measurements

The old way:

Map plaque on a template mounted on cardboard, weigh the whole tooth area on the cardboard, then cut out the pieces of card board covered by plaque and weigh the cut-outs on an accurate scale.

Software is now available that will permit accurate and semi-automated or automated digital measurements of areas of interest in photographed images.
Technical Considerations:

Cost and availability of Equipment
Time required to complete the scoring procedure
Consistent positioning and lighting

The result should be Apples:Apples and not Apples:Oranges comparison.

Other variables inherent in VOHC trials conducted in dogs and cats – body weight, head-shape, age, trial site…….
Digital Measurements

Software is now available that will permit accurate digital measurements.

Extent of coverage: Number of pixels of a defined color as % of overall area of tooth.

Thickness: Depth of color of each pixel (as a measure of the thickness of the disclosed substrate of interest).

Combination of extent and depth would work well for disclosed plaque, but not for undisclosed calculus, as the color of calculus does not deepen with increasing thickness.
History of Plaque Digital Imaging

Extent of coverage vs. Depth of coverage – **Combination** better than either alone.


Digital Dental Imaging in Dogs

Pioneered by Proctor & Gamble for evaluation of dental effectiveness of Eukanuba and IAMS diets by Cox. et al.


Wallis et al, QLF: Waltham, 2015-16.
Calculus


Validation of New Methods

The Conundrum......

Typically, a new method is compared with the current state of the art method.

But the reason for seeking new methods is concern about validity of current methods!

How can a new method be demonstrated to be effective?
VOHC Specifics

Does the current VOHC protocol lend itself to digital scoring techniques?

Number of teeth – the ‘VOHC Set’

- If digital scoring requires the teeth to be lined up in the same plane for a single image, will the Maxillary I3 be out of the depth of field?

- Effect of deleting Max I3 would be simple to analyze, using the extensive data on file with VOHC.

- What is the minimum number of teeth required for a valid imaging analysis
Analysis

Student t-test and ANOVA assume normal distribution of the data (bell-shaped curve).

More likely for quantitative data than qualitative data.

VOHC assumes that data from groups with a group size (‘n’) of 20 or more animals will be normally distributed.
Evidence-based Medicine

The Credibility of Evidence Pyramid for Single Trials:

Blinded
Randomized
Controlled
(BRCT) trials.

The VOHC trial protocols meet the Level 1 standard
Next Steps

There is reason to question current qualitative scoring systems, and there has been sufficient work on development of digital scoring techniques to warrant VOHC determining whether digital scoring systems should be permitted for use in VOHC trials, and perhaps even preferred.

A group of interested, informed individuals is emerging from the process started at the 2015 Veterinary Dental Forum, and continued today, to make an organized effort in this direction.

If you are interested in participating in this open process, please send an email message to VOHC@AVDC.org.