Scoring Plaque and Calculus

Colin Harvey, BVSc, FRCVS, DipACVS, DipAVDC

Director, VOHC

With contributions by Corrin Wallis, PhD,

Waltham Centre for Pet Nutrition
Scoring Plaque and Calculus

This is the third in a series of sessions at the Veterinary Dental Forum and the European Congress for Veterinary Dentistry designed to see if consensus can be reached on 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.
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 indicate twice as much plaque as a score of 2.

**Result:** Accuracy is questionable, and use of parametric statistical tests is questionable.
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 and Size of Teeth

The challenge of assessing % coverage is exacerbated by the irregular shape and wide range in size of the teeth in dogs and cats.

Maxillary canine tooth of a dog

Mandibular first molar tooth of a dog

Shape is more regular in human teeth
What Would Be Ideal for VOHC Use?

1. Quick, accurate, reliable/reproducible, providing quantitative data scoring extent of coverage and thickness of plaque or calculus, similar to a clinical lab chemical analyzer for measurement of e.g. glucose.
2. Not requiring anesthesia or sedation.
3. Suitable for both dogs and cats.
4. As automated as possible, to reduce variability between trials.
5. Technique to be cost-effective.
6. Technique to be publicly available.
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 substrate of interest).
Digital Dental Imaging in Dogs

Pioneered by Proctor & Gamble for evaluation in dogs of dental effectiveness of dental diets by Cox. et al.

Boutoille, Hennet et al: Royal Canin, 2010. The procedure works, but the digital analysis is very time-consuming……

Wallis et al, QLF: Waltham, 2015-16.
From George Stookey:

QLF was developed for the very early detection and quantification of the changes in the mineral content of demineralized areas in advance of the development of carious lesions. My research team at the Indiana School of Dentistry was heavily involved validating the QLF technology.

At that time, use of QLF was labor intensive as each image had to be manually analyzed for mineral content; in our program we had a full-time person that did this. For this reason I spent several years developing a similar version of the instrument with automatic analyses by customized software.

About 10 years ago researchers began studying the use of QLF to quantify plaque. I have no direct experience using QLF for assessing dental plaque (or calculus). I know the folks at Inspektor NV very well.

Let me know whenever I may be of assistance.
Blue light excitation of red extrinsic fluorophores from bacterial metabolites causes red or orange fluorescence. These bacterial metabolites, porphyrins and possibly also extrinsic and intrinsic polysaccharides, are present in old (anaerobic) plaque as well as in calculus.

On the left the ‘normal’ white light image. On the right, the corresponding QLF image. Note the absence of reflections in the QLF image and the red fluorescence corresponding to the areas of plaque seen on the white light image.

From the Inspektor Research Systems, NV web site
History of Plaque Digital Imaging


Bacterial metabolites in plaque or calculus on the tooth fluoresce bright red.
The bacteria identified as producing red fluorescing metabolites are mainly related to periodontitis, and are mostly haemin dependent.
To date, the presence of red fluorescence is considered a property of matured biofilm or plaque associated with poor oral hygiene and with caries.
Inspektor Research Systems NV recently developed the Simple Plaque Score™, which is automatically calculated from fluorescent images:

Visual indication on the original image of all pixels that contributed to the resulting Simple Plaque Score™, which is shown in the upper left corner of the image on the right.
Fast Forward to:

The Quantitative Light-induced Fluorescence technique

Corrin Wallis, Yadvinder Gill, Alison Colyer, Judi Allsopp, Ian Davis, Zoe Marshall-Jones, Gleb Komorav, Sue Higham, Stephen Harris, Lucy Holcombe
Quantitative Light-induced Fluorescence

- Initially developed for measuring dental caries in humans
- Later modified to measure the levels of plaque on the teeth

Image analysis software co-developed with Inspektor Research Systems BV

Less plaque detected in images of undisclosed teeth than disclosed teeth.
Validation of QLF for quantifying feline plaque

Single trial undertaken to determine if the method is:
- Repeatable
- Reproducible
- Comparable to modified Logan & Boyce

12 cats Control diet 4 weeks Dental diet 4 weeks Control diet
12 cats Dental diet

VOHC teeth: Maxillary C, P3 & P4
Mandibular C, P3, P4 & M1
QLF measured a similar reduction in plaque accumulation to modified Logan & Boyce

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean (95% Confidence Interval)</th>
<th>% plaque reduction</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control diet</td>
<td>Dental diet</td>
<td></td>
</tr>
<tr>
<td>Modified Logan &amp; Boyce</td>
<td>4.51 (4.05, 4.97)</td>
<td>3.85 (3.39, 4.31)</td>
<td>14.64 (1.95, 27.34)</td>
</tr>
<tr>
<td>QLF % Plaque Coverage</td>
<td>53.88 (49.41, 58.36)</td>
<td>46.2 (41.77, 50.63)</td>
<td>14.26 (8.9, 19.62)</td>
</tr>
</tbody>
</table>
QLF requires a smaller number of cats than modified Logan & Boyce.

Number of cats required to detect a 15% reduction in plaque build-up when fed a dental diet compared to a control diet in a two-way crossover trial (90% power):

<table>
<thead>
<tr>
<th>Measure</th>
<th>QLF</th>
<th>Modified Logan &amp; Boyce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cats required for 90% power</td>
<td>10</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>
Conclusions

- QLF is a reliable and accurate method for measuring dental plaque in dogs and cats
- QLF is not subjective and requires fewer animals
- QLF images provide a permanent electronic record

<table>
<thead>
<tr>
<th>Reduction</th>
<th>Refinement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in the number of animals used per experiment</td>
<td>Reduced duration of anaesthesia</td>
</tr>
</tbody>
</table>
Calculus


Procedure for coronal calculus: Complete the QLF plaque-scoring procedure, then brush the teeth to remove plaque, reapply the disclosing agent, and repeat the QLF imaging procedure.
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 plaque and calculus scoring methods is concern about validity of the current methods!

How can a new method be demonstrated to be effective?
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 maximum depth.**

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.
‘Thickness Score’
Current Subjective Scoring Methods Cause Distortion

Example: Extent coverage = e.g. 45% = Plaque Extent score is 2 (25-49%).
Thicknes score in area of deepest stain = 3.
Combination Plaque score = \(2 \times 3 = 6\) (maximum score = 12).

But only about 10% of plaque area has thickness of 3, with e.g. 50% of thickness 2 and 40% of thickness 1. Recalculated to reflect varying thickness, score would be \((2 \times 0.1 \times 3) = 0.6\) plus \((2 \times 0.5 \times 2) = 2\) plus \((2 \times 0.4 \times 1) = 0.8\).

Composite Plaque Score = \(3.4\) - about half of the score recorded.
Responses from Erik Van Den Heuvel, CEO of Inspektor Research Systems, NV, the QLF equipment company.

Question: Can QLF be used to develop a plaque measurement that combines coverage and thickness?
Response: Yes, currently plaque coverage is supported. Thickness can also be measured in the future if there is enough demand for it.

Question: Can QLF measure calculus reliably (assuming plaque is brushed off the surface of the calculus)?
Response: Yes, after brushing, calculus can be detected and its coverage can be measured.

Question: Do you think that QLF can provide a reliable, objective and simple to use 'scoring' system for canine and feline plaque and calculus, which VOHC could consider recommending for use in trials that are intended for submission to VOHC.
Response: We have no experience with cats, but our results with imaging canine teeth and quantifying plaque are pretty good. The sensitivity and specificity of QLF is very high. We have numerous scientific articles supporting this.

The Inspektor web site http://www.inspektor.nl/index.php/products provides access to many useful articles about development and use of QLF.
Additional Questions

Digital systems measure the area designated by the software. The primary marker for reducing/preventing periodontal disease is extent and nature of plaque at the gingival margin and sub-gingivally, reflecting the pathogenic potential, and extent of calculus at that same location, enhancing maturation of pathogenic plaque.

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

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?
VOHC Specifics

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

Selection of teeth:

• If digital scoring requires the teeth to be in the same plane for a single image, will the Maxillary I3 be out of the depth of field, or rotated such that the full buccal surface is not included?

• What is the minimum number of teeth required for a valid imaging analysis
Questions

1. Are there other digital measurement techniques/equipment/software out there that would do a similar job to QLF?

2. Since extent-only subjective scoring systems are permitted to be used in VOHC trials, is there reason why QLF scoring of extent of plaque should not be used in VOHC trials?
Next Steps

1. Review whether inclusion of maxillary I3 in the VOHC tooth set is essential. Same for bilateral scoring.

2. Recommendation: Submission of the Waltham QLF data to VOHC with a specific request to permit use of extent-score QLF trials intended for submission to VOHC, similar to the GCPI process.

3. Work with Inspektor Research Systems to develop thickness score software.

4. Work with Inspektor Research Systems to investigate defining the scored areas as e.g. gingival half of the crown half-height.
Discussion?