Diet and Oral Health in Captive Amur Tigers (Panthera tigris altaica)

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Introduction
Oral health problems in felids have become increasingly apparent to zoo veterinarians in recent years9,13,14. The pathogenesis of oral disease may be affected by genetics, age, behavioral and environmental influences as well as by concurrent systemic disease. Excessive calculus accumulation, gingivitis and periodontal disease have been noted in animals offered a commercial, meat-based feline diet. It has been suggested that the soft texture of this diet does not provide adequate abrasive action to clean the teeth as would a firmer-textured natural diet7,10. In dogs, a dry diet is associated with less gingival pathology than is a soft diet3,5. Similar observations were made in a recent study with timber wolves16. Beef bones or oxtails are offered in many zoos as a prophylactic measure to maintain oral health. However, the effectiveness of this practice has not been investigated in a controlled study. This research was designed to explore the effectiveness of bones as a periodic dietary supplement in prevention of plaque and calculus formation and in maintenance of oral health in Amur tigers.

Materials and Methods
Eight adult Amur tigers (Panthera tigris altaica), aged 11 to 17 years, were selected for study while on exhibit at the Detroit Zoological Park in Royal Oak, MI. All animals had been fed a commercially prepared, frozen, beef-based diet* for felids since 1968. Quantities offered had been adjusted to satisfy energy needs for maintenance1. Water was offered ad libitum. The teeth of six of the eight tigers had not been examined or cleaned prior to the study.

At the onset of the study the animals were individually immobilized with tiletamine HCl and 20 zolozepam HCl (Telazol)* (2.2 mg/kg), administered intramuscularly via projectile syringe. Anesthesia was maintained using halothane (0.5-2.5%) inhalation anesthetic. Temperature, pulse, and respiration were monitored periodically. Tooth surfaces were examined, and the condition of gums and teeth was assessed. Depth of the gingival sulcus was measured by inserting a ruled, dental probe between the gums and teeth in four quadrants around maxillary and mandibular premolars and canine teeth. Based on this assessment, the eight animals were randomly allotted from age and sex outcome groups to two groups of similar age range, sex ratio, and oral health. All surfaces of the teeth were scaled and polished with a medium grit fluoride polisher. Long-acting oxytetracycline* (5 mg/kg) was administered intramuscularly prior to recovery.

The tigers were maintained on the commercial feline diet throughout the study. Animals were fasted one day weekly as had been the procedure prior to the onset of this study. In addition, beef femur bones, weighing 1.3-1.8 kg with 3.5 cm thickness of adhering muscle and connective tissue, were offered to four of eight tigers once weekly following the day of fasting. Bones remained in the individual enclosures for 24 hours. Each animal's feed intake was recorded and any changes in health status were noted.

After a 25-week test period, and 72 hours after bones were removed from the

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enclosures, all animals were immobilized. Telazol was administered intramuscularly via projectile syringe for induction, and anesthesia was maintained with halothane as before. The teeth were examined and oral health was assessed. In addition, maxillary premolars and canine teeth were stained with erythrosin disclosing solution, excess erythrosin was rinsed off with water, and the teeth were photographed in a manner similar to previous studies. The tooth image was projected onto paper, and tracings were made of total tooth area and of the stained surface representing plaque and calculus. With the use of a planimeter, tooth surface area and the percentage of tooth surface covered by plaque and calculus were determined. Data from supplemented and control groups were compared using a Federer-Zelen multifactorial analysis of variance and Bonferroni non-orthogonal contrasts.

Three tigers were euthanized after this examination because of poor physical condition associated with long-standing, chronic musculoskeletal problems. The teeth of the remaining five tigers were scaled and polished, and the animals were placed into the same treatment groups as previously. Two tigers received only feline diet, and three received the feline diet plus bones twice weekly (Monday and Friday).

After 42 weeks, ketamine (5 mg/kg) and xylazine (2 mg/kg) were administered intramuscularly via projectile syringe for induction, and anesthesia was maintained with halothane for a final evaluation of oral health. Procedures were followed as in the previous examinations, except the teeth were examined within 48 hours of offering bones to the supplemented group. In addition to staining plaque and calculus and erythrosin as previously, the tooth area occupied by calculus alone was estimated by removing non-adherent plaque with gauze. The two groups were compared statistically as before.

**Results and Discussion**

The initial assessment indicated that oral pathology in older animals affects quantitative measurement of parameters such as gingival sulcus depth, which varied from 5.8 mm in the two eight-year-old tigers and exceeded 9.10 mm in the six animals over ten years of age. However, allotment to treatment was such that pretreatment differences in gingival sulcus depths of supplemented vs. control tigers were not statistically significant.

Periodontal disease and gingivitis were apparent in animals older than ten years. Gingival and subgingival calculus formed in an apparent progression with age, beginning on the buccal surfaces of the third and fourth maxillary premolars of eight-year-old animals, progressing to the maxillary canines, and finally to the buccal mandibular and lingual maxillary surfaces in animals aged 11-17 years.

After 25 weeks, the health of gingivae had improved in both unsupplemented and bone-supplemented tigers, presumably due to the cleaning of all teeth at the beginning of the study. Feeding bones once a week had no significant (P>0.05) effect on maxillary tooth surface area covered by plaque and calculus, although the relatively long period (72 hours) between feeding bones and the oral examination may have influenced this observation. Mean (± SEM) gingival sulcus depth adjacent to maxillary teeth was less (<0.05) in bone-supplemented tigers (6.6 ± 0.6 mm) than in unsupplemented tigers (8.3 ± 0.5 mm). Bones had no significant effect on gingival sulcus depth adjacent to mandibular teeth. Regardless of treatment, plaque and calculus accumulation was greater (P<0.01) on buccal and less (P<0.01) on lingual surfaces of the premolar teeth as compared to either lateral or frontal surfaces of the canine teeth. Also, the depths of the gingival sulcus adjacent to maxillary canines were greater (P<0.01) than adjacent to maxillary premolars. No negative consequences of bone supplementation were noted, and the gross and histopathological evaluation of teeth and gingivae of the three tigers which were euthanized did not reveal...
oral lesions other than those identified during the initial examination. On final examination, after 42 weeks of twice-weekly bone supplementation to the test group, the health of gingivae in both test and control groups had, again, markedly improved, and gingival sulcus depths were less in both groups. The feeding of bones twice a week reduced the maxillary tooth area covered by plaque and calculus combined (P<0.01, Table 1) and by calculus alone (P<0.001, Table 2) as compared to unsupplemented controls. Likewise, bone supplements decreased gingival sulcus depths.

**TABLE 1**
Percentage of maxillary tooth surface area covered by plaque and calculus after 42 weeks of no bones (2 tigers) or bones (3 tigers) twice a week

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Aspect</th>
<th>Treatment*</th>
<th>No bones</th>
<th>Bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt. canine</td>
<td>Lateral</td>
<td>54.6</td>
<td>41.4</td>
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<tr>
<td>Frontal</td>
<td>60.5</td>
<td>48.2</td>
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<tr>
<td>Lt. canine</td>
<td>Lateral</td>
<td>64.7</td>
<td>38.3</td>
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<tr>
<td>Frontal</td>
<td>61.8</td>
<td>42.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rt. P3P4</td>
<td>Buccal</td>
<td>90.8</td>
<td>78.5</td>
<td></td>
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<tr>
<td>Lingual</td>
<td>57.6</td>
<td>28.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. P3P4</td>
<td>Buccal</td>
<td>91.6</td>
<td>82.7</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>54.7</td>
<td>42.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean ± SEM: no bones, 67.0 ± 3.6; bones, 50.3 ± 2.9. Difference was significant (P<0.01).

**TABLE 2**
Percentage of maxillary tooth surface area covered by calculus after 42 weeks of no bones (2 tigers) or bones (3 tigers) twice a week

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Aspect</th>
<th>Treatment*</th>
<th>No bones</th>
<th>Bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt. canine</td>
<td>Lateral</td>
<td>53.6</td>
<td>28.2</td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>43.5</td>
<td>25.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. canine</td>
<td>Buccal</td>
<td>59.6</td>
<td>21.4</td>
<td></td>
</tr>
<tr>
<td>Lateral</td>
<td>60.2</td>
<td>22.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rt. P3P4</td>
<td>Buccal</td>
<td>89.2</td>
<td>22.3</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>56.5</td>
<td>18.6</td>
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<td></td>
</tr>
<tr>
<td>Lt. P3P4</td>
<td>Buccal</td>
<td>89.3</td>
<td>40.5</td>
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</tr>
<tr>
<td>Lingual</td>
<td>54.7</td>
<td>15.8</td>
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<td></td>
</tr>
</tbody>
</table>

*Mean ± SEM: no bones, 63.3 ± 3.1; bones, 24.4 ± 2.5. Difference was significant (P<0.001).

**TABLE 3**
Depth (mm) of gingival sulcus adjacent to maxillary teeth after 42 weeks of no bones (2 tigers) or bones (3 tigers) twice a week

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Aspect</th>
<th>Treatment*</th>
<th>No bones</th>
<th>Bones</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Lateral</td>
<td>7.0</td>
<td>3.3</td>
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<tr>
<td>Medial</td>
<td>7.8</td>
<td>5.7</td>
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<tr>
<td>Lt. canine</td>
<td>Lateral</td>
<td>8.0</td>
<td>4.8</td>
<td></td>
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<tr>
<td>Medial</td>
<td>9.3</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rt. P3</td>
<td>Buccal</td>
<td>4.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>4.8</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. P3</td>
<td>Buccal</td>
<td>4.3</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>5.0</td>
<td>3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rt. P4</td>
<td>Buccal</td>
<td>2.5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>4.0</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lt. P4</td>
<td>Buccal</td>
<td>3.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Lingual</td>
<td>3.5</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mean ± SEM: no bones, 5.3 ± 0.6; bones, 3.5 ± 0.5. Difference was significant (P<0.05).

adjacent to maxillary teeth (P<0.05, Table 3) as compared to controls. Similar differences (P<0.01) in favor of bone supplements were noted for gingival sulcus depths adjacent to mandibular teeth. Gingival sulcus depths adjacent to canines were greater (P<0.05) than depths adjacent to premolars in maxillary and mandibular teeth of both groups.

**Discussion**
It was apparent that prophylactic teeth cleaning had a marked beneficial effect on oral health independent of bone supplementation, and such prophylaxis is recommend for felids whenever the opportunity is presented. Because calculus is primarily bacteria, prophylactic removal of calculus improves gingival integrity by reducing the bacterial load at the gingival border. As a consequence, the bacteremia associated with periodontal disease, that can induce secondary renal and cardiac problems, may be minimized. It should be noted, however, that bacteremia has been noted in association with dental procedures, and it is prudent to use antibiotics prophylactically to minimize secondary infections as a
consequence of these procedures when oral health is particularly poor. Prophylactic antibiotic use also should be considered when initiating a program of bone supplementation if poor oral health is evident.

Bone supplementation on a once-weekly basis resulted in a small improvement in oral health. While gingival sulcus depth was decreased somewhat, plaque plus calculus accumulation was unaffected. Thus, it appeared that bone chewing may have improved gingival integrity but was too infrequent to prevent the accumulation of food debris, associated bacteria and the mineralization of this mass. However, this conclusion may have been affected by the 72 hr delay between offering bones and performing the oral examination.

Twice-a-week bone supplementation clearly improved gingival health and disturbed dental plaque formation sufficiently to promote the plaque accumulation-dislodgement cycle described by Kleinberg12. As gingivitis and the associated swelling decreased, the margins of the gingiva assumed a more normal knife-like edge. Less food was trapped subgingivally, and less substrate was available for growth of oral bacteria. Periodontal pockets observed at the initial examination were decreased in depth or were totally resolved. As a consequence, oral pathology and the possibility of systemic disease secondary to periodontal disease7,13 was much diminished.

The results of this study suggest that, when a soft diet is used for captive felids, twice-weekly supplemental feeding of bones can be an important adjunct to total health management.

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Products Mentioned in Text
c. The Veterinarian Ultrasonic Scaler®, Midwest Veterinary Products Group of American Midwest, Des Plaines, IL 60018.

References

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Dental Crown Restorations on a Snow Leopard

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Paul Brown, D.D.S.**
Robert Turner, D.D.S.**

Introduction

In the spring of 1983 the San Francisco Zoo received a female snow leopard (Panthera uncia) as part of an exotic animal exchange program with the People’s Republic of China. Upon examination, it was found that this nine-year old, seventy-five pound, wild-trapped animal had sustained considerable dental injuries, including fractures of all maxillary and mandibular anterior teeth. The purpose of this paper is to describe the dental procedures undertaken to restore the physiological function of all four canines.

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Diagnosis and Surgery Plan

The maxillary and mandibular central incisors and the four canines had been fractured horizontally. All central and lateral incisors were fractured at the approximate level of the alveolar bone; gingival tissue had grown aggressively over the remaining root structures. There was no sign of pulpal necrosis. Upon x-ray it was apparent that the vital pulp tissue was attached to the surrounding alveolar tissue both at the apex and the coronal end. Consequently a normal healthy environment of the buried roots could be expected.

Three of the four canines were fractured horizontally above the gingival margin. The remaining canine was fractured vertically as well as horizontally below the alveolar ridge. Radiographic examination revealed a relatively short root with an associated chronic periapical abcess, as evidenced by lysis of apical bone in the apical region. This canine had super-erupted until the most coronal surface was supra-alveolar with a flap of redundant tissue over the occlusal surface.

The periodontal status around three of the...