Periodontal disease is the number one diagnosed problem in small animal veterinary medicine.\textsuperscript{1,2} Therefore, treatment and prevention of this malady are the subject of significant research, which has resulted in numerous new products and procedures—in addition to current therapies—to prevent and treat periodontal disease (Table 1).

These methods and products can be grouped into 4 different treatment areas:
1. Removal of infectious agents (pathogen control)
2. Reduction of inflammation and/or bone destruction by the host (host modulation)
3. Regeneration of lost alveolar bone (guided tissue regeneration)
4. Consideration of implants.

**PATHOGEN CONTROL**

It is well known that periodontal disease is initiated by plaque bacteria.\textsuperscript{3} Therefore, the basis for periodontal therapy is, and likely always will be, plaque control. This is best achieved by a combination of thorough professional therapy and home care.

**Professional Therapy**

On the professional side, there are several barrier sealants available, with evidence that they decrease periodontal disease.\textsuperscript{4-6} The other form of professional pathogen control should be periodontal surgery. As discussed in *Proper Diagnosis of Periodontal Disease* (January/February 2015, available at tvpjournal.com), pockets greater than 3 mm in dogs and 0.5 mm in cats are pathologic and require therapy.\textsuperscript{7-10}

In dogs and cats, treat all pockets with closed root planing and, ideally, administration of a sustained-release antimicrobial agent into the

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**TABLE 1. Periodontal Treatment Products**

<table>
<thead>
<tr>
<th>TREATMENT CATEGORY</th>
<th>PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathogen Control</td>
<td><strong>Barrier sealants</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Antiseptics</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Diet</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Antimicrobials</strong></td>
</tr>
<tr>
<td>Host Modulation</td>
<td><strong>Antioxidants</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Nutraceuticals</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Bone Regeneration</strong></td>
</tr>
</tbody>
</table>
pocket if the pockets (Figures 1 to 3):11-14
• Are between 4 and 6 mm in dogs and 1 to 3 mm in cats
• Do not have mobility (Table 2), Stage 2 or 3 furcation exposure (Table 3), or other forms of disease (eg, tooth resorption, endodontic infection).

The sustained-release perioceutic doxirobe has antibacterial, anticollagenase, and antiprostaglandin properties, and also assists in gingival reattachment.

In dogs, pockets greater than 6 mm (Figure 4A) or furcation Stage 2 (Figure 4B) or 3 (Figure 4C) require periodontal flap surgery to effectively clean the root surface and allow for reattachment and infection control.10,15-20

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**TABLE 2. Periodontal Disease Mobility Stages**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>DEFINED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0 (M0)</td>
<td>Physiologic mobility up to 0.2 mm</td>
</tr>
<tr>
<td>Stage 1 (M1)</td>
<td>Mobility is increased in any direction other than axial over a distance of more than 0.2 mm and up to 0.5 mm</td>
</tr>
<tr>
<td>Stage 2 (M2)</td>
<td>Mobility is increased in any direction other than axial over a distance of more than 0.5 mm and up to 1 mm</td>
</tr>
<tr>
<td>Stage 3 (M3)</td>
<td>Mobility is increased in any direction other than axial over a distance exceeding 1 mm or any axial movement</td>
</tr>
</tbody>
</table>

Adapted from avdc.org/nomenclature.pdf

**TABLE 3. Furcation Involvement Stages**

<table>
<thead>
<tr>
<th>STAGE</th>
<th>EXISTS WHEN A PERIODONTAL PROBE EXTENDS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1 (F1)</td>
<td>Less than halfway under the crown in any direction of a multirooted tooth with attachment loss</td>
</tr>
<tr>
<td>Stage 2 (F2)</td>
<td>Greater than halfway under the crown of a multirooted tooth with attachment loss but not through and through</td>
</tr>
<tr>
<td>Stage 3 (F3)</td>
<td>Under the crown of a multirooted tooth, through and through from one side of the furcation out the other</td>
</tr>
</tbody>
</table>

Adapted from avdc.org/nomenclature.pdf

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**Veterinary Oral Health Council**

The VOHC is not a regulatory agency. Submission of clinical trial results to VOHC on behalf of a product is voluntary. If the data submitted demonstrate the required dental efficacy, the VOHC awards its Seal of Acceptance to the product.
demonstrates that periodontal flaps are necessary for thorough cleaning of deep pockets.

These procedures can be learned by general practitioners and require minimal investment in equipment. If such procedures are not an option, these teeth should be extracted.

Home Care
- **Toothbrushing** is still considered the gold standard for dental home care. Acceptable standards for toothbrushing are at least every other day for nonactive periodontal disease to daily brushing for advanced periodontal disease. If clients are educated early about the benefits of brushing, compliance will increase.
- **Topical antiseptics**, such as chlorhexidine and zinc ascorbate, are antimicrobial agents that have been shown to decrease plaque and gingivitis and can be used as adjunct therapy.\(^{21-25}\)
- **A dental diet**—Prescription Diet t/d Canine and Feline (hillsvet.com)—has shown true effectiveness in the treatment of gingivitis. While a claim for gingivitis is no longer allowed, evidence suggests that this and other specifically designed dental diets decrease plaque and calculus accumulation.\(^{26-28}\)
- Rawhide chews and other chew treats are also effective at decreasing plaque and calculus.\(^{29,30}\)

However, many products are not supported by published peer-reviewed studies. For a list of approved products, please visit the Veterinary Oral Health Council’s (VOHC) website, vohc.org.

It has long been thought that traditional dry dog food is good for oral health, and one study appeared to support these claims.\(^{31}\) However, an additional study showed that dry food was not

**FIGURE 4.** Indications for periodontal flap therapy and treatment of a deep periodontal pocket on a maxillary canine. Note that dental radiographs are necessary for any treatment and, if they reveal a significant issue either periodontally or endodontically, periodontal surgery is likely not a good option:
- **A** Intraoral dental picture of a left mandibular first molar (309) in a dog with a 12-mm periodontal pocket. Periodontal flap surgery is necessary for complete cleaning of the root surface; otherwise, extraction is indicated. Note that the teeth are clean and the gingiva appears normal. This demonstrates the importance of anesthetized examinations regardless of outward appearance.
- **B** Intraoral dental picture of a right mandibular first molar (409) in a dog with Stage 2 furcation exposure. Periodontal flap surgery is necessary for complete cleaning of the root surface and furcational area. In addition, this is an excellent candidate for guided tissue regeneration, especially since it is a strategic tooth; alternatively, the tooth could be extracted.
- **C** Intraoral dental picture of a right maxillary fourth premolar (108) in a dog with Stage 3 (through and through) furcation exposure. Periodontal flap surgery is necessary for complete cleaning of the root surface and furcational area. However, extraction is generally the treatment of choice.
FIGURE 5. Indications for periodontal flap therapy and treatment of a deep periodontal pocket on a maxillary canine.

(A) Preoperative intraoral dental picture of a right maxillary canine (104) in a dog. This patient had a 10-mm periodontal pocket with 2 mm of gingival enlargement (8-mm attachment loss). The tooth has been ultrasonically cleaned and hand scaled as evidenced by the clean crown.

(B) Intraoperative intraoral dental picture of a right maxillary canine (104) in a dog demonstrating open root planing with a Gracey curette.

(C) Intraoperative intraoral dental picture of a right maxillary canine (104) in a dog following gingivectomy and periodontal flap elevation. The residual calculus and alveolar bone loss is evident.

(D) Intraoperative intraoral dental picture of a right maxillary canine (104) in a dog following open root planing. Note that the root surfaces are clean and should support reattachment.

superior to moist foods with regard to improving oral health.32

HOST MODULATION
As stated previously, plaque has been identified as the etiologic agent of periodontal disease.

- Bacteria and their byproducts create inflammatory changes that may result in alveolar bone loss in susceptible individuals.

- The inflammation is caused by bacteria; however, the patient’s immune response to the inflammation determines (or controls) the progression of the disease.33-36

- If the acute inflammatory response is resolved quickly, tissue injury is prevented. However, inadequate resolution and failure to return tissue to homeostasis result in neutrophil-mediated destruction and chronic inflammation of the periodontal ligament and alveolar bone.8,34-37

**Host modulation** is a new technique for treating periodontal disease that controls the patient’s response to infection and inflammation. Numerous preparations have shown promise in decreasing the amount of inflammation and

What Is Nrf2?
Nrf2 is a protein messenger in cells that regulates the expression of antioxidant proteins that protect against oxidative damage triggered by injury and inflammation. Several drugs that stimulate the Nrf2 pathway are being studied for treatment of diseases that are caused by oxidative stress.
osteoclastic bone resorption in cases of chronic periodontitis. In addition, several drug therapies have good efficacy in slowing the progression of periodontal disease.38-52

Many of these preparations have substantial adverse effects, which make their use questionable.53 However, an increasing number of products are natural products or nutraceuticals with minimal to no adverse effects.

**Inflammatory Mediators**

As stated earlier, resolution of inflammation (and return to homeostasis) prevents osteoclastic bone resorption.

**Nonsteroidal Anti-inflammatory Drugs.** Control through classic anti-inflammatory pathways is effective but typically associated with significant adverse effects. Numerous nonsteroidal anti-inflammatory drugs (eg, cyclooxygenase-1 and -2 inhibitors) have been helpful in decreasing periodontal disease and alveolar bone loss.54-61 However, these products appear most effective in the short term.38,39

**Antimicrobials.** Antimicrobials are another group of medications with significant promise both locally and systemically; in particular, the tetracycline class and especially doxycycline (2 mg/kg PO Q 24 H life long62). These are typically used below the antimicrobial dose needed for their anti-inflammatory properties. Numerous human studies now support long-term administration of low-dose doxycycline after periodontal therapy has been performed.40-42

**Bioactive Products.** Lipoxins, resolvins, and protectins are a new family of bioactive products of fatty acids, such as eicosapentaenoic acid, that may decrease periodontal inflammation.43-51 Topical application of resolvin E1 (RvE1) in rabbit periodontitis protected against inflammation-induced tissue and bone loss associated with periodontitis.44 An additional study showed that topical application of RvE1 in rabbits had dramatic effects on the regeneration of periodontal tissues destroyed by periodontal disease.52 These products may represent a future option for the control of periodontal inflammation and secondary alveolar bone loss.

**Antioxidants**

Several recent studies have linked chronic oxidative stress with periodontal disease (Table 4).63-67 Furthermore, antioxidant capacity is decreased in patients with established periodontal disease (particularly those with diabetes mellitus).68,69 Finally, proper equilibrium between free radicals and antioxidants is now thought to be the main prerequisite for healthy periodontal tissue.70 Therefore, antioxidants appear to be an important aspect of periodontal health, and supplementation may have protective qualities.71

Numerous methods and products are available for increasing antioxidant capacity. These can range from simple vitamin supplementation (vitamins C and E)72,73 to specific products that more effectively increase total antioxidant capacity.

- **Topical application of antioxidants improves periodontal health.**74,75 In addition, a veterinary-specific formulation (Antioxidant Oral Gel and Breath Renewal System, toothtotail.com) decreases halitosis in dogs.76
- **On the systemic side, Nrf2 (see What Is Nrf2?) triggers production of superoxide dismutase, glutathione, and catalase, which helps protect against free radicals, and may have benefits for treating periodontal disease.77,78 A natural product with a veterinary-specific formulation (LifeV Antage Canine Health, lifevantage.com/IVS) stimulates antioxidant production in the body and in humans increases the levels of natural antioxidants far more than vitamin supplementation alone.79,80

**Nutraceuticals**

**Fatty Acids.** Recent studies on the use of fatty acid supplements have shown beneficial results in periodontal inflammation.81-86 However, because of the high epithelial penetration of fatty acids,
FIGURE 6. Indications for guided tissue regeneration.

(A) Intraoral dental picture of a 14-mm periodontal pocket on the palatine aspect of the left maxillary canine (204) in a border terrier. Note that this pocket does not communicate with the nasal cavity. If this was the case, an oronasal fistula would be present and extraction the only reliable treatment.

(B) Intraoral dental radiograph of a vertical (angular) defect on the distal surface of the distal root of the right mandibular first molar (409) (red arrow). Note that the second molar appears to be periodontally healthy (blue arrow).

(C) Intraoral dental picture of a left maxillary fourth premolar (208) in a dog with Stage 2 furcation exposure on the palatine aspect. Periodontal flap surgery is necessary for complete cleaning of the root surface and furcational area. In addition, this is an excellent candidate for guided tissue regeneration, especially since it is a strategic tooth. Alternatively, the tooth could be extracted. Note that this tooth is clean with minimal gingival inflammation, which demonstrates the importance of anesthetized examinations and probing, regardless of clinical signs. In addition, the palatal involvement requires a thorough examination.

topical application may be favorable for the treatment of local oral inflammatory diseases, including periodontitis.

A particular fatty acid, 1-tetradecanol complex, is an esterified monounsaturated fatty acid with positive effects in rabbits. In 2 in vivo studies on New Zealand rabbits, topical administration stopped the progression of periodontal disease and significantly reduced macroscopic periodontal inflammation, attachment, and bone loss. Histologic assessment demonstrated that it also inhibited inflammatory cell infiltration and osteoclast activity.

Other Nutraceuticals. Milk basic protein (MBP) supplementation is effective in increasing bone mineral density (BMD), and this increase in BMD may be primarily mediated through the promotion of bone formation and inhibition of bone resorption. When administered at high doses, it has been shown in experimental rat models to aid in the recovery of periodontally lost alveolar bone.

Coenzyme Q10 deficiency has been shown in humans with periodontal disease. Conversely, supplementation (systemic or topical) may have a beneficial effect on periodontal health in humans. Studies in humans have also demonstrated that folic acid is effective in preserving gum tissue and reducing risk for gingivitis and periodontitis.

Nutrition

Finally, proper nutrition (see Home Care, page 87), including vitamin supplementation, appears to be an important aspect of periodontal care. Studies have found that vitamin supplementation provides beneficial effects for periodontal patients.
BONE REGENERATION

Regenerating bone lost via periodontal disease is another targeted therapy. Guided tissue regeneration (GTR) has been used for decades, but recent advances in barriers and bone grafting have markedly improved the success rates.103-106

Regardless, only a handful of conditions carry a good prognosis for bone regeneration. The best prognosis is seen with:107

• 3-walled periodontal pockets typically seen on the palatal aspect of the maxillary canine (Figure 6A) and distal aspect of the distal root of the mandibular first molar (Figure 6B)
• Lesions with Stage 2 furcation (Figure 6C).

Because these are common conditions in small breed dogs, many patients may benefit from these procedures.

The theory of GTR is that the downward growth of faster healing soft tissue must be prevented to allow the slower growing bone and periodontal ligament to repopulate the periodontally induced bony defect (Figure 7 and Figure 8, page 92).108,109 The procedure involves:107

1. Creating a periodontal flap
2. Performing open root planing (the first 2 steps create a clean root surface for healing)
3. Filling the defect with bone augmentation
4. Placing a barrier membrane.

Numerous products are used in humans, but the products of choice for most veterinary dentists are cancellous freeze-dried demineralized bone for the graft and demineralized laminar bone sheets as the membrane.107, 110-114

IMPLANTOLOGY

While rare (and controversial)115 in veterinary dentistry, implantology is exceedingly common in human dentistry (Figure 9, page 92). It is increasingly being used in place of traditional methods, such as periodontal surgery and even endodontics.

The main reason for the use of implants is that they are associated with a better long-term prognosis than periodontal surgery or endodontics.
in advanced disease. Therefore, they provide a good option for maintaining teeth and removing a potentially infected or painful tooth earlier in the course of disease. If an implant could be performed in a pet with advanced disease, it may convince the client to remove an infected tooth.

Some have voiced concerns that there is minimal clinical evidence that these procedures work in veterinary patients. However, most research for humans was performed on dogs, and the results were very positive. The other issue with this form of therapy is the numerous anesthesias required, but advances in technology and techniques will likely improve this in the near future. Adequate bone density is needed to accommodate this type of therapy.

IN SUMMARY

- New passive pathogen (plaque) control measures are coming out all the time. For many of these, no research exists, so look beyond the advertisements for research, or use the VOHC for confirmation before making your recommendations.
- Deep periodontal pockets require periodontal flap surgery or extraction, and some of these teeth can be saved with GTR.
- Host modulation therapy is likely the future of periodontal therapy.
- Nutraceuticals, antioxidants, vitamins, and proper nutrition all play a role in supporting good periodontal health. These treatments, in combination with new local bone regenerating products (such as BMP) and implantology, will dramatically change the way we treat periodontal disease.

Without mechanical removal of the causative agent of periodontal disease, these treatments...
are not effective. However, if proper pocket augmentation is accomplished, these therapies provide the opportunity to re-establish bone attachment and minimize inflammatory reactions associated with all phases of periodontal disease.

BMD = bone mineral density; GTR = guided tissue regeneration; MBP = milk basic protein; RvE1 = resolvin E1; VOHC = Veterinary Oral Health Council

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