Correlation between the periodontal treatment and ecocardiographic changes in adult dogs

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Abstract: Periodontal disease is commonly diagnosed in dogs and has been associated with systemic lesions in several organs, however, studies correlating this oral condition with heart disease in the canine species are still scarce in the scientific literature. Thus, the objective of the present study was to evaluate such correlation in adult dogs, through serial echocardiographic exams and, nonetheless, to analyze the influence of dental treatment on cardiac function. For this, 60 dogs were used, distributed in two groups, the control (CG, n = 30: presence of periodontal disease, not submitted to oral treatment) and the treated (GT, n = 30: presence of periodontal disease and submitted to oral treatment). The animals of the CG were paired with those of the GT in terms of race, weight, age and degree of periodontal disease. Baseline echocardiographic examinations (D0) of the CG were performed and after 30 days (D30). In GT, examinations were also performed at D0 and D30, however, they were submitted to periodontal treatment after baseline measurements. The echocardiographic exams were performed at the Veterinary Cardiology Laboratory of the Veterinary Hospital of the University of Franca, to record and analyze the interventricular septum in diastole (SIVd), interventricular septum in systole (SIVs), diameter of the left ventricle in diastole (DVEd), left ventricular diameter in systole (EVDs), left ventricular free wall in diastole (PVEd) left ventricular free wall in systole (PVEs) shortening fraction of left
ventricle (FS), final diastolic volume (VDF), final stroke volume (VSF), ejection fraction (EF), maximum pulmonary artery pressure gradient (max. GP AP) and left atrial and aortic artery diameter ratio (EA-AO). The results of the CG were statistically compared with those of the GT by means of simple analysis of variance (ANOVA). The data obtained regarding the SIVs, DVEd and PVEs parameters of the GT dogs at D30 showed a statistically significant decrease ($p<0.05$) when compared to the D30 of the CG. Thus, given the established methodology and the results found, it is possible to infer that periodontal treatment may benefit some cardiac parameters of adult dogs, improving their quality of life and survival.

**Keywords**: Echocardiogram; Periodontitis; Systemic diseases; Veterinary cardiology.

**Introduction**

The periodontal disease (periodontitis) is considered the most common oral affection in small animals, affecting about 75.0% of dogs aged between four and eight years. Periodontitis is considered the most common cause of oral infections and tooth loss in these species (EMILY et al., 1999; GIOSO, 2003; NIEMIEC, 2008).

Periodontal disease is characterized by inflammation and progressive destruction of periodontal tissues, which protect (gum) and support (cementum, alveolar bone and periodontal ligament) the dental elements (VELDEN, 2000; GIOSO, 2003; ROZA, 2004; ARTESE et al., 2010).

The etiological agent of periodontal disease is bacterial plaque, formed by the association of several bacteria, food debris, leukocytes, macrophages, mineral salts, metabolites and oral desquamation cells (GRUBBS et al., 2017). With the organization and interaction of bacterial plaque constituents, there is the production of by-products that contaminate the entire oral cavity and damage periodontal and adjacent structures, by triggering an immune response, with consequent production of prostaglandins, activation of enzymes such as collagenases, proteases and stimulation of osteoclasts (WIGGS; LOBPRISE, 1997; SAN ROMÁN, 1999).

Bacterial plaque is a yellowish, viscous-looking material that is constantly formed and organized (every 24-48 hours) and, if not removed, will mineralize (due to salivary mineral salts precipitation) and form the dental calculus (odontolite), which will adhere to the teeth and predispose to the progression of oral disease, by facilitating the adherence of more dirt and possible pathogenic microorganisms (SAN ROMAN, 1999; GIOSO, 2003; HARVEY, 2005).
The gum is the first structure to be affected, which causes a clinical condition of gingivitis, which has symptoms such as inflammation, vasodilation, edema and sensitivity, being reversible if the underlying cause is removed (ABUSLEME et al., 2013; CHANG et al., 2017). With the non-removal of the etiological agent, there will consequently be an evolution of the oral disease, and with it, destruction of the alveolar bone, which will be reabsorbed by the action of local bacteria along with the osteoclasts, and with that, formation of the periodontal pocket, which is located between the tooth and the remaining bone, predisposing to the accumulation of dirt and bacterial proliferation, making the period of periodontitis more severe and progressive (GIOSO, 2003; ROZA, 2004; CHANG et al., 2017).

Since the alveolar bone works as a bulkhead for the gum, after bone resorption, a gingival retraction process begins, which can generate exposure of the tooth root and furcation of multirooted teeth. With this exposure of the root, the cementum that protects it, as it is a fine structure, is quickly lost and leads to situations of tooth sensitivity (CHANG, et al., 2017). With the advancement of periodontal disease, the periodontal ligament is also injured and thus the tooth becomes mobile and is easily lost. Bone resorption is continuous, predisposing to fractures of the mandible and/or maxilla, in addition to oronasal communications, which alters oral function and aesthetics (GIOSO, 2003; ROZA, 2004; HIRAI et al. 2013; KITSHOFF et al., 2013).

The clinical signs of periodontal disease vary according to the host's condition and the degree of the disease (GIOSO, 2003; ROZA, 2004) and include halitosis, hyperemia, bleeding and gingival ulcers, tooth loss and oronasal communications are due to bone resorption, nasal discharge, facial swelling, fracture of the maxilla and mandible, dysphagia, sialorrhea and systemic changes (SANTOS; CARLOS; ALBUQUERQUE, 2012; CARREIRA; DIAS; AZEVEDO, 2015; SILVA et al., 2017).

According to Roza (2004), periodontal disease is progressive and classified according to the degree of involvement of the periodontal: grade 0: absence of oral symptoms; grade I: accumulation of bacterial plaque and mild gingivitis; grade II: bacterial plaque accumulation, gingivitis and gingival edema; grade III: gingivitis and beginning of periodontal pocket formation; grade IV: deep periodontal pocket, onset of bone loss and tooth mobility and grade V: bone loss, significant tooth mobility and predisposition to fracture of the mandible and/or maxilla.

Depending on the patient's nature, sedation or general anesthesia is required to perform a specific and complete physical examination of the oral cavity to define the
diagnosis of periodontal disease. In this, one must evaluate not only the dental elements, but all the structures that make up the stomatognathic system (SANTOS; CARLOS; ALBUQUERQUE, 2012). Together, complementary exams such as blood tests, extra and intraoral x-rays help to establish periodontal disease and its respective degrees, facilitating the therapeutic approach (HARVEY; EMILY, 1993; ROZA, 2004).

The treatment of periodontal disease aims to recompose the oral anatomy and physiology, eliminate the etiological agent including the removal of dental calculus, root planing, dental extractions, polishing of the remaining dental elements, among others (GIOSO, 2003; ROZA, 2004).

To prevent periodontal disease, the best method is regular toothbrushing, at least three times a week with the aid of a soft veterinarian or human pediatric toothbrush, associated with veterinary toothpaste (WIGGS; LOBPRISE, 1997; SAN ROMÁN, 1999, ROZA, 2004; WATANABE et al., 2015). Veterinary dentifrices do not have soaps like humans, in addition to having an attractive flavor for animals (meat) and the presence of some products in their composition to prevent the formation and adherence of bacterial plaque (SAN ROMÁN, 1999; ROZA, 2004).

The periodontal disease, in addition to predisposing the occurrence of local changes, can cause systemic damage (ARTESE et al., 2010). Due to the rich vascularization of the periodontium and tooth movement within the dental alveolus, microorganisms and their metabolites can enter lymphatic and blood vessels leading to bacteremia during the animal's chewing and the patient's systemic immune response can predispose to the formation of immune complexes in the bloodstream (GIOSO, 2003; RAWLINSOM et al., 2011; SANTOS; CARLOS; ALBUQUERQUE, 2012).

Immune complexes can adhere to the walls of the endothelium, causing local inflammation and endothelial lysis, as this is a chronic process, it can lead to failure of various organs (KOTERGAARD; ERIKSEN; BAELOM, 2014; ALMEIDA et al., 2017, KANG et al., 2017) such as liver, nervous system, kidneys, joints, and heart, especially in senile patients (RAWLINSOM et al., 2011; KOTERGAARD; ERIKSEN, BAELOM, 2014; ALMEIDA et al., 2017, KANG et al., 2017).

In humans, the periodontal disease is directly associated with arteriosclerotic vascular disease and thromboembolism and, consequently, a reduction in cardiac output. Also, several periodontal pathogens were found in atheroma plaques, such as *Porphyromonas gingivalis*, *Prevotella intermedia*, *Tannerella forsythensis* and *Actinobacillus actinomycentemcomitans* (LOCKHART et al., 2012). In veterinary
medicine, scientific studies proving the link between periodontal disease and cardiovascular diseases are scarce. Still on this theme, Lemsaddek et al. (2016) demonstrate this association through the presence of Enterococcus spp in the gums and heart of dogs affected by periodontal disease. However, so far, there are no scientific studies that relate the advantages of periodontal treatment with echocardiographic changes in dogs.

Given the high incidence of periodontal disease in small animals, especially dogs, and the possible local and systemic impairments, this study aimed to evaluate the correlation of periodontal treatment with cardiac abnormalities in adult dogs, through serial echocardiographic examinations.

**Research design**

The current work was approved by the Animal Use Ethics Committee (CEUA) of the University of Franca, UNIFRAN (process nº 4182260917).

Sixty dogs from the Animal Dentistry sector of the Veterinary Hospital of the University of Franca (UNIFRAN) were used. Of these, 30 dogs composed the control group (CG: presence of periodontal disease, not submitted to periodontal treatment) and 30, the treated group (TG: presence of periodontal disease and submitted to oral treatment).

Participants in the CG were matched with those in the TG regarding race, weight, age and degree of periodontal disease, and the classification of oral disease was carried out by clinical inspection, always by the same dental professional.

All 60 animals underwent baseline echocardiographic examination (D0). The dogs in the CG were not treated and, after 30 days, underwent another echocardiographic examination (D30). On the other hand, the TG dogs underwent conventional periodontal treatment and, after 30 days of this therapy, another echocardiographic examination was performed (D30).

All echocardiographic examinations (D0 and D30 of the 60 dogs) were performed at the Veterinary Cardiology Laboratory of the Veterinary Hospital of UNIFRAN, with the aid of the EnVisor C HD device (Philips®, 8 or 4 MHz probes), always by the same specialist professional, with the animals mechanically restrained.

During the echocardiographic examinations, measurements were recorded and evaluated in monodimensional mode (M mode), regarding the interventricular septum in diastole (IVSd in cm), interventricular septum in systole (IVSs in cm), diameter of the
left ventricle in diastole (LVDd in cm), left ventricular diameter in systole (LVDs in cm), free wall of the left ventricle in diastole (LVWd in cm), free wall of the left ventricle in systole (LVWs in cm) (Figure 1), left ventricular shortening fraction (FS in %), end-diastolic volume (EFV in ml), end-systolic volume (EFV in ml), ejection fraction (EF in ml), pulmonary artery maximum pressure gradient (PG max. PA in mmHg) (Figure 2) and ratio of the diameter of the left atrium and the aorta artery (LA-AO in cm) (Figure 3).

![Figure 1](image_url)

**Figure 1.** Echocardiographic measurements of an adult dog, performed in monodimensional mode (M mode), of the parameters interventricular septum in diastole (IVSd), interventricular septum in systole (IVSd), left ventricular diameter in diastole (LVDd), left ventricular diameter in systole (LVDs), left ventricular free wall in diastole (LVWd) and left ventricular free wall in systole (LVWs).

**Source:** Cardiology Department of the Veterinary Hospital of the University of Franca (UNIFRAN).
Figure 2. Echocardiographic measurement of an adult dog, performed in monodimensional mode (M mode), of the measurement of the maximum pulmonary artery pressure gradient (PA max. GP).
Source: Cardiology Department of the Veterinary Hospital of the University of Franca (UNIFRAN).

Figure 3. Echocardiographic measurement of an adult dog, performed in monodimensional mode (M mode), comparing the diameter of the left atrium and the aorta artery (LA-AO ratio).
Source: Cardiology Department of the Veterinary Hospital of the University of Franca (UNIFRAN).
For the dogs in the TG, regardless of the degree of oral disease, systemic antibiotic therapy was prescribed (Clindamycin 11 mg/kg, orally, every 12 hours for four days before and three days after the dental procedure). After food and water fasting, they were general anesthetized with inhalation, the anesthetic protocol depending on the individual condition of each patient. Then, the oral cavity was cleaned with 0.12% mouthwash chlorhexidine gluconate followed by removal of odontoliths with dental ultrasound and surgical maneuvers or not, according to the degree of periodontitis of each patient, following the recommendations of Gioso (2003).

The results obtained in the CG were statistically compared with those of the TG, both in D0 and D30, in an attempt to investigate whether periodontal treatment benefited the established cardiological parameters. For this, the data obtained were statistically verified by simple analysis of variance (Two-Way ANOVA) and later by the Sidak test, for fully randomized experiments, with calculation of the F statistic and its respective "P-value", using the program Graphpad Prism® 8.0.

**Results**

The Average and standard deviations of the echocardiographic parameters of the dogs in the control group (CG) and treated group (TG), at different moments of analysis (D0 and D30), are shown in Table 1.

It was noted that the echocardiographic parameters IVSs, LVDd, and LVWs of dogs in the TG on D30 showed a statistically significant decrease \( (p<0.05) \) compared to D30 in the CG. The other echocardiographic measurements did not show statistical difference regarding the experimental group and analysis time.
In veterinary medicine, studies correlating periodontal disease with cardiovascular diseases are scarce in the scientific literature, as well as the benefits of periodontal treatment regarding the echocardiographic parameters of dogs, restricting the discussion. Thus, most of the times, the results are compared with those described in human medicine (LOCKHART et al., 2012; SILVA et al., 2017; SAFFI et al., 2018).

According to the largest treatment center for cardiac diseases in Brazil (INCOR), 40% of human patients with bacterial endocarditis demonstrate as a triggering factor, Table 1. Average and standard deviation of echocardiographic parameters: interventricular septum in diastole (IVSd), interventricular septum in systole (IVSs), left ventricular diameter in diastole (LVDd), left ventricular diameter in systole (LVDs), left ventricular free wall in diastole (LVWd), left ventricular free wall in systole (LVWs), left ventricular shortening fraction (FS), end diastolic volume (VDF), end systolic volume (ESV), ejection fraction (EF), pressure gradient maximal pulmonary artery (GP max. AP) and ratio of the diameter of the left atrium and aortic artery (LA-AO) of dogs in the control group (CG, n=30, untreated) and the treated group (TG, n= 30, undergoing periodontal treatment) at different times of analysis (D0 and D30).

<table>
<thead>
<tr>
<th>Echocardiographic parameters</th>
<th>GROUP CONTROL (CG)</th>
<th>TREATED GROUP (TG)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>D0</td>
<td>D30</td>
</tr>
<tr>
<td>IVSd (cm)</td>
<td>0.90±0.24</td>
<td>0.89±0.29</td>
</tr>
<tr>
<td>IVSs (cm)</td>
<td>1.10±0.30</td>
<td>1.16±0.35</td>
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<tr>
<td>LVDd (cm)</td>
<td>3.26±1.02</td>
<td>3.42±1.06</td>
</tr>
<tr>
<td>LVDs (cm)</td>
<td>2.21±0.82</td>
<td>2.11±0.7</td>
</tr>
<tr>
<td>LVWd (cm)</td>
<td>0.89±0.38</td>
<td>0.86±0.30</td>
</tr>
<tr>
<td>LVWs (cm)</td>
<td>1.13±0.34</td>
<td>1.22±0.45</td>
</tr>
<tr>
<td>FS (%)</td>
<td>32.92±9.58</td>
<td>38.53±6.78</td>
</tr>
<tr>
<td>FDV (ml)</td>
<td>72.92±141.03</td>
<td>55.5±36.64</td>
</tr>
<tr>
<td>FSV (ml)</td>
<td>20.3±16.67</td>
<td>17.33±13.2</td>
</tr>
<tr>
<td>FE (ml)</td>
<td>0.62±0.14</td>
<td>0.69±0.08</td>
</tr>
<tr>
<td>PG máx. PA (mmHg)</td>
<td>2.93±1.07</td>
<td>3.00±1.40</td>
</tr>
<tr>
<td>LA-AO (cm)</td>
<td>1.02±0.17</td>
<td>1.12±0.24</td>
</tr>
</tbody>
</table>

* Significantly different from D30 in CG (p<0.05).

Discussion
In veterinary medicine, studies correlating periodontal disease with cardiovascular diseases are scarce in the scientific literature, as well as the benefits of periodontal treatment regarding the echocardiographic parameters of dogs, restricting the discussion. Thus, most of the times, the results are compared with those described in human medicine (LOCKHART et al., 2012; SILVA et al., 2017; SAFFI et al., 2018).

According to the largest treatment center for cardiac diseases in Brazil (INCOR), 40% of human patients with bacterial endocarditis demonstrate as a triggering factor,
microorganisms from the oral flora and which are commonly found in infectious processes of periodontal origin (BARROSO; CORTELA; MOTA, 2014). In accordance with these descriptions, Lemsaddek et al. (2016) indicated the association of periodontal disease with cardiac involvement, through the concomitant presence of Enterococcus spp in the gums and heart valves of dogs.

The present study aimed to investigate possible advantages of periodontal treatment on echocardiographic parameters in adult dogs, since bacterial endocarditis, characterized by the adhesion of microorganisms in the endocardium, can progress to thromboembolic diseases, with consequent reduction in cardiac output and worsening of myxomatous degeneration. valve (ÁVILA et al., 2011; LOCKHART et al., 2012), which is the most common heart disease in the canine species, being associated with high mortality (KITTLÉSON, 2008). Thus, as heart failure secondary to bacterial endocarditis can cause a valvular murmur and influence the thickness of the interventricular septum in systole (SIVs), the size of the diameter of the left ventricle in diastole (LVD) and the free wall of the left ventricle in systole (PVEs), the results found suggest benefits of periodontal treatment, as the dogs in the TG on D30 showed a significant decrease in the aforementioned echocardiographic parameters, when compared with the control animals. Furthermore, it should be considered that these results were observed in the short term (30 days) after periodontal treatment, and more echocardiographic advantages could be detected with this therapy instituted in the long term.

Also, as bacterial endocarditis is difficult to diagnose in animals (SANTOS, 2012), the importance of associating the results of this work with pro-inflammatory markers, recognized as risk indicators for cardiovascular diseases such as C-reactive protein, is highlighted, IL-6, fibrinogen and total leukocyte count, as suggested by Lockhart et al. (2012).

Among the local clinical signs caused by periodontal disease in dogs, gingivitis, ulcers and oral sensitivity, gingival retraction due to alveolar bone resorption with exposure of cementum, in addition to mobility and loss of dental elements stand out (WIGGS; LOBPRISE, 1997; GIOSO, 2003; ROZA, 2004), which predispose to difficulty in capturing food and chewing, especially commercial dry food (SAN ROMÁN, 1999). Thus, the reduction in food consumption, with a consequent decrease in the water content of the diet, can influence the greater consumption of water intake and, in addition, the offer of moist diets by tutors, which have about 70% more water
than conventional ones, increasing the volume and directly reflecting on the cardiac output (DIBARTOLA, 2007). Cardiac output (systolic volume x heart rate) which corresponds to the volume of blood ejected per minute is one of the most important parameters of cardiovascular function, and its oscillation can result in impairment of cardiac function (ABBOTT, 2006).

As a result of cardiac effort, it is possible to detect echocardiographic changes such as increased left ventricular wall in systole (LVPs) and increased interventricular septum in systole (IVSs) even in cases of pressure overload in the left ventricle due to volume changes (TILLEY; GOODWIN, 2002; BARROSO; CORTELA; MOTA, 2014), which significantly reduced in animals undergoing periodontal treatment in this study, compared to control dogs.

Also in this theme, according to the Frank-Starling mechanism, the increase in the diameter of the left ventricle in diastole (LVDd) is related to the ability of the heart to adapt to variations in volume (BARROSO; CORTELA; MOTA, 2014) and, as in In this study, dogs undergoing periodontal treatment showed a significant reduction in this parameter on D30, it is assumed that this therapeutic option may be advantageous with regard to echocardiographic changes.

Given the numerous local and systemic changes that periodontal disease can cause in small animals, especially in dogs (EISNER, 1989; DE BOWES et al., 1996), the importance of instructing tutors on the best way to prevention with regular toothbrushing (at least three times a week) with veterinary toothpaste (FERNANDES et al., 2012; LEMSADDEK et al., 2016), which prevents the organization of bacterial plaque, keratinizes the gums, in addition to favoring the increase in local microcirculation is also considered a simple, fast and low-cost procedure (WIGGS; LOBPRISE, 1997; SAN ROMÁN, 1999; ROZA, 2004).

**Conclusion**

Based on the methodology applied and the results obtained, it is assumed that the echocardiographic parameters referring to the interventricular septum in systole (IVSs), left ventricular diameter in diastole (LVDd) and the free wall of the left ventricle in systole (LVWs) showed a reduction significant in adult dogs undergoing periodontal treatment compared to control animals, suggesting that this therapeutic option can improve the quality of life and survival of those affected.
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References


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