Periodontitis and Obstructive Sleep Apnea: A Literature Review

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INTRODUCTION

Obstructive sleep apnea (OSA), a chronic multifactorial respiratory disease, consists of a temporary decrease or cessation of breath for ≥ 10 seconds and leads to a reduction in blood oxygen saturation of more than 3% to 4% and/or neurological arousal.1–3 OSA involves the upper respiratory tract, and it has been proven that snoring and OSA have systemic consequences in humans.4 It has been recently suggested that OSA may be related to periodontitis, another chronic multifactorial disease.5,6 Periodontitis is characterized by chronic inflammation of tooth-supporting tissues.1,5,6 In addition, these conditions are associated with similar systemic inflammatory responses and involve common inflammatory mediators such as interleukins, metalloproteinases, and tumor necrosis factor (TNF)-α.

Indeed, both conditions have been shown to be associated with the development of systemic diseases including cardiovascular diseases and diabetes.3,5,7 An association between these conditions could also have repercussions on the practice of dentistry and medicine. In order to guide the health care professional on diagnostic methods, risk factors, and treatments, the research is currently focused on whether there is a causal relationship between periodontitis and OSA. This would not only encourage more comprehensive dental care but also contribute to establish a partnership between the dentist and the physician.

Objective

This review of the literature aimed to evaluate the current evidence regarding the association between periodontitis and OSA and the potential mechanisms involved.

METHODS

Electronic Search

A systematic approach was used to identify articles investigating a potential association between periodontitis and OSA. A detailed search of PubMed electronic literature with a 10-year limit (2006 to October 2016) was applied. The search strategy involved the following keywords: “obstructive sleep apnea” AND “periodontal disease.”

Selection of Studies

Selection of studies by title and abstracts review was carried out individually by each of the 6 reviewers (CT, PB, CB, CAG, SG, MM). To be eligible, studies had to investigate whether there was an association between the two conditions. Abstracts of articles not covering the subject of association were eliminated. The original article of the incomplete abstracts was revised for further details.

RESULTS AND DISCUSSION

Thirty-six publications were initially selected. However, 25 articles were rejected for lack of emphasis on one or both conditions. For example, the focus for several studies was on obesity, diabetes, cardiovascular disease, and OSA therapeutics. Consequently, only 11 studies were included in this literature review (see Figure 1).

In the selected studies, the apnea-hypopnea index (AHI) and the oxygen saturation rate were the objective measures frequently used to diagnose and measure the severity of obstructive sleep apnea.
OSA. Some authors have, however, relied on more subjective determinants such as the STOP-1 and Berlin11,12 questionnaires. In regard to periodontitis, clinical parameters including pocket depth, level of clinical attachment, gingival recession, salivary and plasma cytokine levels, and plaque and gingival index were used.1–3,5–7,10,13 From articles on the association of chronic periodontitis with OSA, the following hypotheses linking these pathologies were described: systemic inflammation mediators in periodontitis can also increase the risk of cardiovascular, cerebrovascular, and pulmonary disease as well as type 2 diabetes, rheumatoid arthritis, osteoporosis, pregnancy complications, osteonecrosis, and even types of cancer. In comparison, OSA would promote an increase in adhesion molecules, C-reactive protein, transcription factor (nuclear factor-kB), certain inflammatory cytokines (interleukin [IL]-1B, IL-6, TNF-α), and an activation of circulating neutrophils. This inflammatory condition also potentiates several systemic diseases such as certain cardiovascular, cerebrovascular, pulmonary, and neurocognitive diseases as well as type 2 diabetes and rheumatoid arthritis.

Gunaratnam et al. reported for the first time in 2009 that there may be an inflammatory link between periodontitis and OSA. They noted a high prevalence of periodontal disease in subjects with OSA (77% to 79%) but could not assert a causal link due to a significant lack of correlation of the measures. Nevertheless, they suggested that periodontitis may be one of the co-factors involved in the association between apnea and cardiovascular disease, or that a preexisting OSA could worsen the presence and severity of periodontal disease. Following these hypotheses, several studies (Table 1) have investigated the presence of an association between OSA and periodontitis.

Nizam et al.9 have shown that OSA does not have a prominent effect on salivary IL-1B, IL-21, and PTX3, inflammatory markers of periodontitis (Table 3). However, they found that salivary IL-6 and IL-33 tend to increase in patients with apnea, regardless of severity, whereas IL-33 levels appear to decrease with the evolution of chronic periodontitis. Thus, being in higher concentration during periodontitis, only the salivary IL-6 could be related to the elevation found in OSA. This could then reflect the degree of subclinical inflammation present in the periodontal tissues and partly explain the pathogenesis. This potential cause-effect relationship has unfortunately not been fully demonstrated in another subsequent case-control study by the same authors. Larger population studies with different periodontal disease categories are needed to confirm this link and to test the possibility of a dose-response relationship. No differences were statistically significant with these same cytokines in serum according to the studies by Nizam et al. However, some studies have demonstrated a correlation between plasma IL-6 and TNF-α with moderate to severe OSA and periodontitis. It is suggested that this difference may be related to body mass index, periodontal diagnosis, and demographic status variations between studies.

Chronic Systemic Inflammation

First, there is the hypothesis of systemic dissemination of inflammatory markers triggered by the chronic inflammation of periodontal tissues encountered in periodontitis. This inflammation is caused by the host immune response following the exposure to periodontal pathogens such as Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola, and Prevotella intermedia. This host response causes an increase in systemic inflammatory factors by destroying the integrity of periodontal tissues. In patients with periodontitis, there is an increase in certain inflammatory cytokines and mediators as well as an increase of the C-reactive protein, an important systemic inflammatory marker. The increase in inflammation mediators in periodontitis can also increase the risk of cardiovascular, cerebrovascular, and pulmonary disease as well as type 2 diabetes, rheumatoid arthritis, osteoporosis,
### Table 1—Summary of cross-sectional studies analyzing the association between periodontitis and OSA.

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>OSA Assessment</th>
<th>Periodontitis Assessment</th>
<th>Results</th>
<th>Limitations</th>
<th>Conclusion</th>
</tr>
</thead>
</table>
| Sales-Peres et al. 2016<sup>10</sup> | • Brazil  
  • n = 108  
  • Mean age: 40.1 (30–60 years)  
  • Ratio M/F: 23/85  
  • BMI > 40 or ≥ 35 kg/m² (class 3 obesity) | • Bq  
  • ESS | • Periodontal parameters (6 points/teeth; full mouth, clinical attachment, bleeding, calculus and gingival index)  
  • Periodontitis severity scale by AAP and CDC in 2007<sup>10</sup> and modified in 2012<sup>17</sup> | • Periodontitis is not associated with ESS or with Bq  
  • Gingivitis is not associated with ESS or with Bq | • Morbidly obese patients, common risk factor for both conditions  
  • Diagnostic questionnaire for OSA and no PSG (risk of bias at the classification level)  
  • The plaque index was not evaluated | • No significant association between periodontitis and OSA in class 3 obese patients |
| Loke et al. 2015<sup>2</sup> | • United States  
  • n = 100  
  • Mean age: 52.6 (26–79 years)  
  • Ratio M/F: 9/11 | • PSG  
  • AHI classification  
  ○ Normal  
  ○ Mild (5–15)  
  ○ Moderate (> 15–30)  
  ○ Severe (> 30) | • Periodontal sampling (6 points/teeth; full mouth excluding third molars), recession, clinical attachment, bleeding, plaque %, % of pocket depth ≥ 5 mm, % loss of attachment loss ≥ 3 mm  
  • Periodontitis severity scale by AAP and CDC in 2007<sup>10</sup> and modified in 2012<sup>17</sup> | • AHI: 26 normal, 21 mild, 19 moderate, 34 severe  
  • Moderate to severe periodontitis: 73%  
  • No significant difference in the prevalence of periodontitis between the 4 groups of AHI  
  • A significant association between plaque % and AHI after adjustment for age  
  • Logistic regression to predict moderate/severe periodontitis with AHI, age, and smoking reported a significant association with age only | • High prevalence of periodontitis in subjects, which does not represent the population of the United States (44.7%)  
  • MF ratio not balanced | • No significant association between OSA and moderate to severe periodontitis except for plaque % and AHI |
| Seo et al. 2013<sup>3</sup> | • Korea  
  • n = 687  
  • Mean age: 55.85 ± 6.63 (47–77 years)  
  • Ratio M/F: 460/227 | • PSG and questionnaire assessing sleep at home  
  • AHI classification  
  ○ Normal  
  ○ Mild (≤ 5)  
  ○ Moderate (5–10)  
  ○ Severe (> 10) | • Periodontal parameters (6 points/teeth; Ramfjord’s teeth 16, 21, 24, 36, 41, 44), recession, clinical attachment, bleeding, plaque (Silness & Loe) and gingival index  
  • Definition of periodontitis: ≥ 4 teeth with at least 1 site interproximal probing of ≥ 4 mm and attachment loss of ≥ 6 mm on the same tooth | • Prevalence of periodontitis: 17.5%  
  • Prevalence of OSA (AHI ≥ 5): 46.6%  
  • 60% of patients who received a diagnosis of periodontitis had OSA  
  • Compared to the control group, patients with OSA (AHI ≥ 5) are usually associated with periodontitis, pockets of ≥ 4 mm, clinical attachment losses of ≥ 6 mm  
  • Periodontitis is associated with OSA (AHI ≥ 5) in the age group of ≥ 55 years but not in the < 55 years age group* | • Partial periodontal examination; only 6 teeth were evaluated; possibility of underestimating the disease  
  • Some confounding factors have not been evaluated  
  • There is no calculation of the size of the target sample | • Significant association between OSA and periodontitis |
| Gunaratnam et al. 2009<sup>9</sup> | • Australia  
  • n = 66  
  • Mean age: 54.9 ± 12.8 (18 to > 75 years)  
  • Ratio M/F: 54/12 | • PSG  
  • AHI classification  
  ○ Normal  
  ○ With OSA (> 5)  
  • Only patients with OSA are selected in this study  
  • Patients from a national survey were used as an OSA free control group | • Periodontal parameters (6 points/teeth, full mouth), clinical attachment loss, bleeding, plaque (Silness & Loe) and gingival (modified Lobene) index  
  • Periodontitis severity scale by the AAP and the CDC<sup>10</sup> and the NCHS<sup>10</sup> | • Prevalence of periodontitis: 77% to 79% according to the definition used  
  • Significant association between clinical attachment loss and total sleep time | • The prevalence of periodontitis represents a 4x higher prevalence than the Australian National Survey of Adult Oral Health  
  • Some confounding factors are not assessed  
  • Database for OSA-free controls  
  • Small sample size  
  • Potential examiner bias due to absence of masking | • Association between OSA and periodontitis  
  • Higher prevalence of periodontitis in patients with OSA than in patients without OSA |

* = adjusted for age, sex, BMI, alcohol, tobacco, snoring, mouth breathing during sleep, and diabetes. AAP = American Academy of Periodontology, AHI = apnea-hypopnea index, BMI = body mass index, Bq = Berlin questionnaire, CDC = Centers for Disease Control and Prevention, ESS = Epworth Sleepiness Scale, NCHS = National Center for Health Statistics, OSA = obstructive sleep apnea, PSG = polysomnography.
This finding contradicts in part the previously described pathophysiological relationship, establishing a proportional relationship between plasma MMP-9 and the severity of OSA.\textsuperscript{29,31} Again, these differences may be related to various periodontal diagnostics and demographic status from these studies.

### Mouth Breathing

Second, there is the hypothesis that mouth breathing would be indirectly associated with periodontitis through changes it can cause in the oral environment. In a healthy patient with no nasal involvement, mouth breathing accounts for approximately 4% of total ventilation.\textsuperscript{3} This percentage tends to increase with aging. In a study by Seo et al.,\textsuperscript{5} the prevalence of mouth breathing appeared to be higher in patients with OSA. By generating dry mouth, this type of breathing tends to diminish the self-cleansing and antibacterial effect of saliva. It is then possible to note an increase in bacterial colonization and subsequent gingival inflammation. These two factors may increase the risk of developing periodontal disease or trigger its progression.\textsuperscript{13} However, in this study, the presence of mouth breathing was subjectively measured using a questionnaire, which limits the interpretation of the results. A case-control study using another type of questionnaire demonstrated an opposite relationship between mouth breathing and periodontitis.\textsuperscript{1} It is suggested that a more objective approach (for example, using the AHI) be used in subsequent studies. Confirmation of a bidirectional relationship between OSA and periodontitis through mouth breathing remains to be proved.\textsuperscript{13}

### Common Risk Factors

Finally, the third hypothesis often presented in the literature is the comorbidity relationship between the two conditions, given that they have several common risk factors such as tobacco use, sex (male), aging, alcohol consumption, obesity, and diabetes.\textsuperscript{1,3,5,7,9,10} In periodontitis, we also observe ethnicity (Hispanic and African), stress, social class, and poor oral hygiene.\textsuperscript{1,6} The simultaneous presence of periodontitis and OSA in an individual would then be attributable to the common risk factors and would act as a comorbidity link in contrast to the first two assumptions where there is a causal link.\textsuperscript{8} It should also be noted that periodontitis is a common disease. According to the National Health and Nutrition Examination Survey, it would affect up to 47.2% of the population in the years 2009–2010.\textsuperscript{8} According to a study by Lee et al.,\textsuperscript{32} OSA would reach 2% to 4% of middle-aged Caucasian men and women. It is therefore to be expected that these two conditions may very well be present in the same individual without there necessarily being a causal link between them.

As a result of these studies, a systematic review and meta-analysis was published by Al-Jewair in 2015.\textsuperscript{8} Including 6 studies, the authors concluded that an association is still

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### Table 2—Summary of case-control studies analyzing the association between periodontitis and OSA.

<table>
<thead>
<tr>
<th>Studies</th>
<th>Population</th>
<th>OSA Assessment</th>
<th>Periodontitis Assessment</th>
<th>Results</th>
<th>Limitations</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keller et al.</td>
<td>Taiwan</td>
<td>Initial diagnosis provided by the LHD2000 and ICD-9 codes</td>
<td>Periodontal parameters (6 points / teeth; full mouth), probing depth ≥ 3 mm is considered to be periodontitis</td>
<td>Prevalence of periodontitis: 33.8% (2,474) cases versus 22.6% (4,960) controls</td>
<td>Retrospective study; No adjustment for several confounding factors (eg, family history, tobacco, occupations); Incomplete definition of chronic periodontitis</td>
<td>Significant association between OSA and chronic periodontitis diagnosis</td>
</tr>
<tr>
<td>Ahmad et al.</td>
<td>United-States</td>
<td>STOP screening questionnaire</td>
<td>Multiple calibrated examiners</td>
<td>Periodontitis prevalence: 32.6%</td>
<td>Subjective OSA diagnosis; Low prevalence of periodontitis compared to national average</td>
<td>Significant association between moderate to severe periodontitis and an elevated risk for OSA</td>
</tr>
<tr>
<td></td>
<td>n = 154</td>
<td></td>
<td></td>
<td>Periodontal parameters (6 points / teeth, full mouth), recession, clinical attachment, bleeding, plaque and gingival index</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o 50</td>
<td></td>
<td></td>
<td>Radiographs to determine bone levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>participants with moderate to severe periodontitis</td>
<td></td>
<td></td>
<td>ADA moderate or severe periodontitis\textsuperscript{1}</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o 104</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>controls/ gingivitis or mild periodontitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Mean age: 61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18 to ≥ 70 years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Ratio M/F: 61/93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* = adjusted for age, sex, BMI, alcohol, tobacco, difficult nasal breathing, diabetes, dry mouth, education and income. ADA = American Dental Association; ICD-9, International Classification of Diseases, Ninth Revision; LHD2000 = Longitudinal Health Insurance Database 2000; OSA = obstructive sleep apnea.
possible but that the recent evidence is insufficient to support a causal link, or to assert that the treatment of periodontitis has a significant effect on OSA.\textsuperscript{1,2,5,6,9,10} Thus, for the time being, it is preferable to refer to systemic inflammatory pathways common to the two diseases where further studies will be required to fully demonstrate a cause-and-effect relationship.\textsuperscript{8,13} As such, a 2016 study by Al Habashneh et al. including 294 men in Jordan evaluated this association link.\textsuperscript{11} The Berlin questionnaire was used to assess the risk of OSA. Subjects at high risk of OSA were more frequently and severely affected by periodontitis (odds ratio = 2.3 with 95\% confidence interval = 1.03–5.10) than those at low risk of OSA. However, the diagnostic value of the Berlin questionnaire remains debatable in comparison to polysomnography and this study was only carried out with male subjects.

**Limitations**

There are inevitable limitations in the collection of data and the comparative analysis between several studies. Thus, the research methods and conclusions of the studies often differ from each other. Among others, compared to the study by Gunaratnam et al. where the odds ratio between periodontitis and OSA was almost 4,\textsuperscript{6} according to Keller,\textsuperscript{10} this ratio would be closer to 1.75. The case-control study of Ahmad et al. also came to the conclusion that there was an association.\textsuperscript{1} However, unlike the study by Gunaratnam et al., patients did not receive a clinical diagnosis before they were categorized with OSA. The study used a validated questionnaire (STOP) to obtain an estimate of the risk of OSA.\textsuperscript{1}

In contrast, Loke et al. concluded that there was a significant association between OSA severity and plaque percentage but no correlation between OSA and the prevalence of moderate or severe periodontitis.\textsuperscript{2} These examples of contradictory results demonstrate the importance of the limiting factors present in the studies.

The selection of cases in the studies can be done either by using databases of patients who have responded positively to questionnaires or by means of an examination done clinically. It is evident that an individualized and standardized approach is more accurate for the diagnosis of periodontal diseases.\textsuperscript{10} Despite the calibrated classification of the periodontal disease, the case-control division is performed using various measures that can be influenced by the operator. Measurement of plaque

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**Table 3**—Inflammatory cytokines and their association with periodontitis and OSA.

<table>
<thead>
<tr>
<th>Salivary Cytokines</th>
<th>Role</th>
<th>Statistical Association With Periodontitis ((P &lt; .05))</th>
<th>Statistical Association With OSA ((P &lt; .05))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interleukin-1 (IL-1B)</td>
<td>• Proliferation, differentiation and lymphocyte apoptosis</td>
<td>• No\textsuperscript{9}</td>
<td></td>
</tr>
<tr>
<td>Interleukin-6 (IL-6)</td>
<td>• T lymphocyte proliferation • Differentiation of B lymphocytes • Stimulation for immunoglobulin secretion • Active bone resorption</td>
<td>• Yes\textsuperscript{9}</td>
<td>• Yes, if moderate or severe OSA\textsuperscript{2,5}</td>
</tr>
<tr>
<td>Interleukin-21 (IL-21)</td>
<td>• Proliferation of NK and cytotoxic T lymphocytes</td>
<td>• Yes\textsuperscript{9} • Significant correlation between clinical attachment loss and levels of IL-21\textsuperscript{9}</td>
<td>• No\textsuperscript{9}</td>
</tr>
<tr>
<td>Interleukin-33 (IL-33)</td>
<td>• Production of T helper-2-associated cytokines • Anti-inflammatory activity</td>
<td>• No\textsuperscript{9}</td>
<td>• Yes, if moderate or severe OSA\textsuperscript{9}</td>
</tr>
<tr>
<td>Pentraxin-3 (PTX-3)</td>
<td>• Innate immunity • Control of inflammation • Destruction of apoptotic cells</td>
<td></td>
<td>• No\textsuperscript{9}</td>
</tr>
<tr>
<td>Tumor necrosis factor-alpha (TNF-(\alpha))</td>
<td>• Control of the production of prostaglandins, collagenases, cytokines, cell adhesion molecules, bone resorption factors</td>
<td></td>
<td>• No\textsuperscript{9}</td>
</tr>
<tr>
<td>Receptor activator of nuclear factor kappa-B ligand (RANKL)</td>
<td>• Osteoclastogenesis</td>
<td></td>
<td>• No\textsuperscript{9}</td>
</tr>
<tr>
<td>Osteoprotegerin (OPG)</td>
<td>• Osteoclastogenesis</td>
<td></td>
<td>• No\textsuperscript{9}</td>
</tr>
</tbody>
</table>

OSA = obstructive sleep apnea.

**Table 4**—Peptide hormone and its association with periodontitis and OSA.

<table>
<thead>
<tr>
<th>Peptide Hormone (Serum)</th>
<th>Role</th>
<th>Statistical Association With Periodontitis ((P &lt; .05))</th>
<th>Statistical Association With OSA ((P &lt; .05))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apelin</td>
<td>Physiological respiration</td>
<td>Yes, if severe OSA\textsuperscript{2,21}</td>
<td></td>
</tr>
</tbody>
</table>

OSA = obstructive sleep apnea.
level, bleeding, mobility, furcation defect, and loss of attachment by several operators using different techniques may create a certain variance and a margin of error. In addition, not all studies used the same definition of periodontitis, which could lead to underestimation or over-estimation of prevalence. In addition, the geographical location may vary from one study to another, which leads to the lack of uniformity in the prevalence and severity of the disease.

Being aware of the initial hypotheses, the objectivity of the examiner may be biased during the periodontal data collection, hence the need for a blind approach. In addition, some studies are limited to a partial periodontal evaluation of the mouth compared to others with 6 measurement points for each tooth. In order to make an objective diagnosis of OSA, in contrast to the rather subjective approach of the STOP or Berlin questionnaires, polysomnography assessing rapid eye movement, oxygen saturation index, and AHI were used.

In general, it is also possible that in a patient treated for periodontitis, OSA is more likely to be diagnosed in comparison with a person unaware of having this condition. This might again increase the correlation rate.

**Future Research and Current Practice Suggestions**

Carra et al. recently published a study on the potential improvement of periodontitis with CPAP and/or BPAP. This treatment with a facial mask, a novel therapy for OSA, may include a humidification device, which reduces dry mouth. Even if the link between mouth breathing associated with OSA and periodontitis is still debated to this day, this device opens several avenues of research. This study failed to observe a difference in inflammation, plaque, calculus, number of missing teeth, or masticatory function between individuals using these devices and those who did not use them. However, this study has some limitations. Patients using the CPAP/BPAP could have been particularly motivated to maintain their oral hygiene and receive regular medical follow-ups. Also, the controls were subjectively selected using a questionnaire and the adhesion of the CPAP/BPAP could not be measured. The potential presence of patients with asymptomatic or undiagnosed OSA in the control group is another limitation. Thus, one cannot conclude if this OSA therapy has a beneficial effect on the periodontitis, even if it succeeds in decreasing mouth breathing.

In light of recent studies, a diligent dentist could incorporate new OSA front-line detection techniques into his or her clinical evaluation. According to Ahmad et al., on average, a patient visits the dentist more often than his or her physician. Having

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**Table 5—Salivary or plasma enzymes and their association with periodontitis and OSA.**

<table>
<thead>
<tr>
<th>Enzymes</th>
<th>Statistical Association With Periodontitis ($P &lt; .05$)</th>
<th>Statistical Association With OSA ($P &lt; .05$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProMMP-2</td>
<td>Salivary</td>
<td>Inversely proportional and statistically significant association$^7$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>No$^7$</td>
</tr>
<tr>
<td>MMP-2</td>
<td>Salivary</td>
<td>Yes$^{28}$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>Yes$^{28}$</td>
</tr>
<tr>
<td>ProMMP-9</td>
<td>Salivary</td>
<td>No$^7$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>Inversely proportional and statistically significant association with severe OSA$^1$</td>
</tr>
<tr>
<td>MMP-9</td>
<td>Salivary</td>
<td>Yes$^{28}$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>Proportional and statistically significant association$^{29}$</td>
</tr>
<tr>
<td>Neutrophil elastase</td>
<td>Salivary</td>
<td>Inversely proportional and statistically significant association$^7$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>No$^7$</td>
</tr>
<tr>
<td>Myeloperoxidase (MPO)</td>
<td>Salivary</td>
<td>No$^7$</td>
</tr>
<tr>
<td></td>
<td>Plasma</td>
<td>No$^7$</td>
</tr>
</tbody>
</table>

OSA = obstructive sleep apnea.
the responsibility to promote oral health and hygiene, it was suggested that the STOP questionnaire (Appendix 1, supplemental material) be included in the dental examination. As a rapid and effective method, this self-reported questionnaire identifies patients at risk for sleep apnea without, however, providing a categorical diagnosis. The integration of this questionnaire could thus intercept systemic diseases. Collaboration and possible exchange of results between the dentist and the family physician would then be necessary in order to carry out a more objective examination such as polysomnography or polygraphy.

CONCLUSIONS

To date, association studies between OSA and periodontitis are often based on different diagnostic criteria and show conflicting results. The many limiting factors and the difficulty in recruiting high numbers of participants preclude scientists and clinicians from drawing any conclusions. However, there seems to be a possible link between periodontitis and OSA syndrome via plasma and salivary inflammatory markers. Despite recent awareness, few studies have specifically focused on these aspects. Thus, well-structured, randomized control trials are needed to confirm this association and to clarify the mechanism of interaction between the two conditions.

REFERENCES


**SUBMISSION & CORRESPONDENCE INFORMATION**

Submitted for publication April 25, 2017
Submitted in final revised form April 25, 2017
Accepted for publication July 13, 2017

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**DISCLOSURE STATEMENT**

The authors report no financial conflicts of interest.