Review

Is There a Positive Effect of Smoking Cessation on Periodontal Health? A Systematic Review

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Background: Although the detrimental effects of tobacco on the periodontal tissues have been reported extensively, little is known about the potential beneficial effect of smoking cessation on periodontal health. The aim of this systematic review is to evaluate the effect of smoking cessation on periodontitis progression and response to periodontal therapy.

Methods: Two independent reviewers completed the review process through title (n = 118), abstract (n = 24), and whole-paper selection (n = 5). Sources include Medline and EMBASE databases (up to December 2012) and a reference list of selected studies. Prospective studies comparing progression rates of periodontitis between smokers and quitters and clinical trials evaluating the effect of smoking-cessation programs, alone or in combination with periodontal treatment, were included. At least 1 year of follow-up was required for inclusion.

Results: Of 331 potentially relevant publications, five studies fulfilled the inclusion criteria. Because of heterogeneity of the studies, a meta-analysis could not be performed. One study reported that the progression of clinical attachment loss (AL) ≥3 mm during a 6-year period was approximately three times higher among smokers than quitters (P <0.001). Two studies (10 and 20 years of follow-up) observed a decrease in radiographic bone loss of ≈30% among quitters when compared with smokers. Among individuals receiving non-surgical periodontal treatment, quitters were more likely to have periodontal probing depth reductions (P <0.05) than non-quitters/oscillators. No differences in AL were observed.

Conclusion: Based on the limited available evidence, smoking cessation seems to have a positive influence on periodontitis occurrence and periodontal healing. *J Periodontol 2014;85:83-91.*

KEY WORDS

Alveolar bone loss; periodontal attachment loss; periodontitis; review; smoking cessation; tobacco use cessation.

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Tobacco use is an important risk factor for several diseases, including different types of cancer, respiratory infections, and cardiovascular diseases.[1] According to the World Health Organization, tobacco is associated with ≈6 million deaths each year,[2] and the cost related to its use approaches $200 billion per year in the United States alone.[3] The detrimental effects of tobacco on oral health have also been investigated extensively. Smokers have higher risk for precancerous lesions and oral cancer,[4,5] periodontal disease,[6] tooth loss,[7,8] and oral implant failure.[9,10]

Smoking is a well-established independent risk factor for periodontitis.[11,12] There is also recent evidence that smoking may interact with other factors, including genetics[13] and diabetes,[14] to potentiate periodontal breakdown.[15,16] Smoking not only increases disease occurrence, but it also impairs periodontal treatment.[17,18] There is a wealth of evidence showing that tobacco smoking favors the establishment of a pathogenic microflora, decreases immune host response, and increases the release of proinflammatory mediators.[19,20] Nevertheless, these mechanisms have not been fully explored.[21,22]

Smoking-cessation initiatives have reduced smoking-related morbidity and mortality, representing a cost-effective health promotion initiative.[23,24] In this

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context, it has been suggested that smoking-cessation programs could help prevent a large proportion of new cases of periodontitis in several populations. Estimates suggest that smoking could be responsible for approximately half of the cases of periodontitis in the United States[25,26] and one-third in Australia.[27] Susin et al.[28] projected that smoking cessation could prevent up to 90,000 cases of severe periodontitis in an urban population in southern Brazil. Hujoel et al.[29] estimated that severe periodontitis incidence decreased 31% from 1955 to 2000, attributable to a decrease in the number of smokers in the United States population. These estimates underscore the great positive effect that smoking cessation might have on periodontal health. Indirect evidence supports this contention because epidemiologic studies[25,26] have observed a lower likelihood of periodontitis among former versus current smokers.

Despite the strong evidence supporting the detrimental effect of smoking on periodontal health and the potential benefit of smoking cessation on periodontitis incidence, few studies have evaluated the effect of smoking cessation on periodontal health. The aim of the present systematic review is to assess the effect of smoking cessation on periodontitis incidence, progression, and response to treatment.

MATERIALS AND METHODS

The present systematic review reports the results according to guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses.[30]

Focused Questions

There are two focused questions: 1) What is the effect of smoking cessation on periodontitis incidence and progression among adults? and 2) What is the effect of smoking cessation on periodontal treatment outcomes among adults?

Criteria for Study Selection

Two types of studies were eligible for inclusion: 1) prospective studies comparing incidence and/or progression rates of periodontitis between smokers and quitters; and 2) intervention studies evaluating the effect of smoking-cessation programs alone or in combination with periodontal treatment. Only studies including individuals who quit smoking at or immediately after enrollment were considered for inclusion. A period of at least 1 year of follow-up was required for inclusion. Cross-sectional studies and case series were not included.

Smoking Cessation

Smoking-cessation status was defined based on self-reported data and/or biochemical markers. Smoking-cessation programs were defined as structured interventions, including but not restricted to the following: 1) counseling, 2) cognitive behavioral therapy, 3) nicotine supplements, 4) medication, and 5) motivational techniques.

Outcomes

The primary outcome was clinical attachment level (CAL). Secondary outcomes included the following: 1) periodontal probing depth (PD), 2) radiographic bone level, and 3) bleeding on probing (BOP).

Literature Search

A search of Medline and EMBASE databases (no range limit) up to December 2012 was performed. No language restrictions were used. Only human studies were included. The search strategy used the following terms: (smoking cessation [MeSH terms] OR smoking quitting OR tobacco use cessation [MeSH terms] OR tobacco quitting) AND (periodontal disease OR periodontitis OR clinical attachment level OR alveolar bone loss OR tooth loss OR periimplantitis). In addition, reference lists of selected publications were searched.

Studies Selection and Data Extraction

Two reviewers (TF and MLM) independently screened titles and abstracts through the databases. Any discrepancies were solved by consensus between the reviewers or by arbitration (CS). Data from the selected studies were selected independently by three reviewers (TF, MLM, and CS).

RESULTS

The electronic search identified 326 potentially relevant studies. Five additional studies were identified by hand search, resulting in 331 studies. Of these, 307 studies were excluded after reviewing the title and abstract. The full text of 24 studies was evaluated, and only five fulfilled the inclusion criteria. Figure 1 presents a flowchart of the selection process.

Reasons for exclusion of full-text articles include the following: 1) participants did not stop smoking during the study;[6,7,31-35] 2) cross-sectional design;[8] 3) primary and secondary outcomes were not evaluated;[36-40] 4) lack of control group;[41,42] 5) <1 year of smoking cessation;[39] and 6) other types of publications (letters/editorials).[14,43-45]

The five studies[46-50] included were performed in four different countries and were published from 1993 to 2011. Sample sizes ranged from 49 to 810 participants, and follow-up ranged from 1 to 20 years. Methodologic characteristics of the three observational and two interventional studies included in this review are described in Tables 1 and 2, respectively. A meta-analysis could not be

performed because of the heterogeneity of data reported.

Prospective Studies

Only one prospective study that investigated the effect of smoking cessation on CAL progression could be identified[50] (Table 3). Thomson et al.[50] evaluated, during a period of 6 years, a representative birth cohort of 26-year-old New Zealanders. The smoking rate decreased from 38.3% at baseline (aged 26 years) to 31.5% after 6 years (aged 32 years), representing an effective smoking-cessation rate of 18%. The overall 6-year progression of CAL ≥3 mm in this sample was 12.7%. Smokers had approximately three times higher progression of CAL ≥3 mm (28.4%) than individuals who quit smoking after baseline (10.1%, P <0.001). There were no significant differences in periodontal health between never-smokers and quitters.

Two prospective studies evaluated progression of radiographic bone loss in a Swedish cohort.[46,47] A decrease in radiographic bone loss of ≈27% and 31% was observed for quitters when compared with smokers during 10 and 20 years of follow-up, respectively (Table 3). The rate of radiographic bone loss among quitters approximated that of non-smokers in both studies. No data regarding CAL were available for these studies.

Interventional Studies

No randomized clinical trials evaluating different smoking-cessation strategies (including different levels of pharmacotherapy and/or behavioral support) alone or in combination with periodontal treatment were found. Two single-arm clinical studies assessing the combined effect of non-surgical periodontal treatment and smoking cessation including nicotine replacement and pharmaceuticals were identified.[48,49] To assess the potential added benefit of smoking cessation on periodontal treatment, these studies stratified the participants according to smoking status during the study into three groups: 1) quitters; 2) smokers; and 3) oscillators.

Table 4 describes main characteristics and results of the two clinical studies included in this review. Conflicting results were observed for these studies. Whereas Preshaw et al.[48] found that quitters were significantly more likely to have PD reductions ≥2 mm than non-quitters and oscillators, Rosa et al.[49] did not observe significant differences between quitters and smokers/oscillators. No significant differences in CAL gain, BOP reduction, and radiographic bone levels were observed between quitters and smokers in both studies.

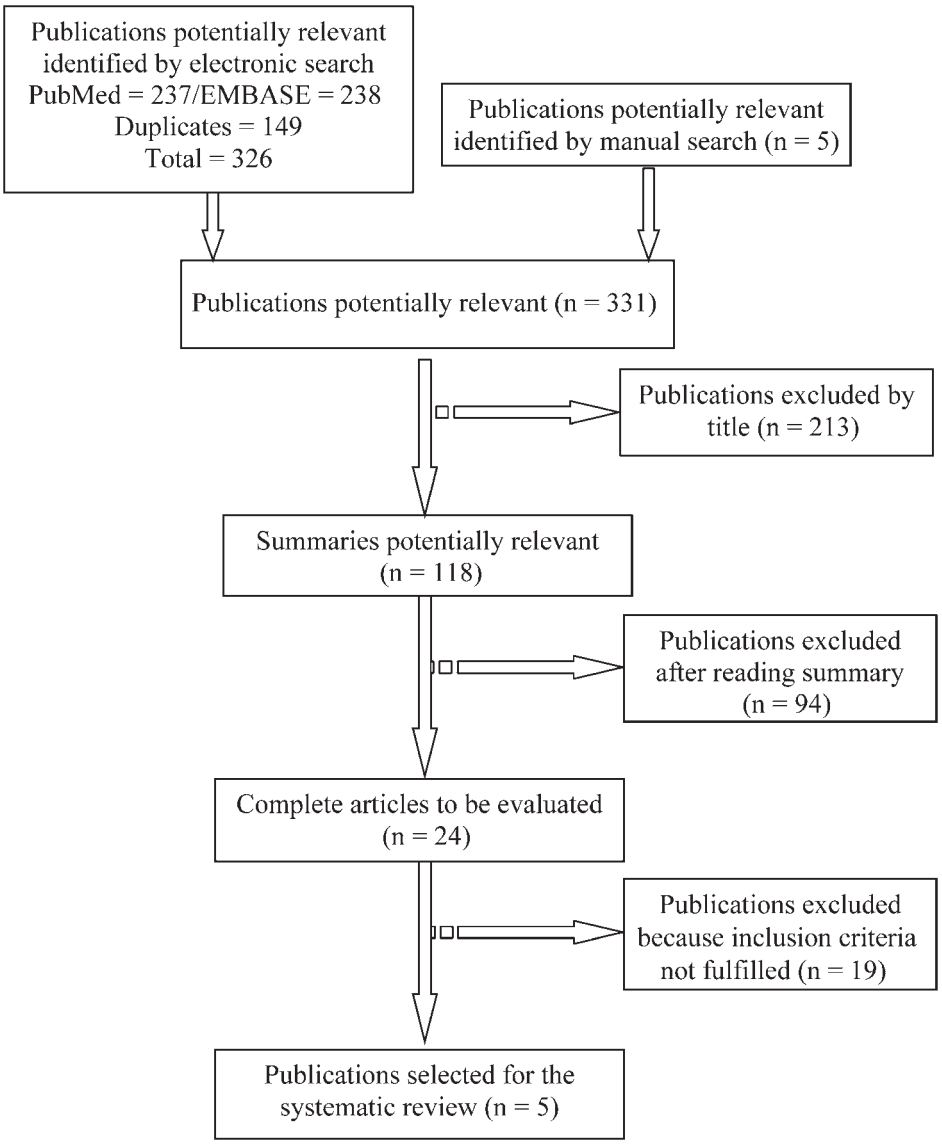

Figure 1.
Flowchart of the selection process.

Table 1.

Methodologic Quality Assessment for the Observational Studies

Criterion	Bolin et al., 1993[46]	Jansson and Lavstedt, 2002[47]	Thomson et al., 2007[50]
Sample-size calculation	No	No	No
Clear eligibility criteria	No	No	No
Confounding control	Not clear	Not clear	Yes
Examiner reliability	No	No	Yes (ICC for CAL = 0.69; 95% CI = 0.66 to 0.86)
Dropout rate (%)	Not reported	Not reported	8.5
Smoking-cessation rate (%)	24.04	43.20	17.4
Smoking-cessation compliance assessment	Self-reported	Self-reported	Self-reported
Statistical analysis	Not adjusted for participation rate and other confounders	Not adjusted for participation rate and other confounders	Not adjusted for participation rate and other confounders
Follow-up	10 years (from 1970 to 1980)	20 years (from 1970 to 1990)	6 years (from 1998/1999 to 2004/2005)

ICC = intraclass correlation coefficient; 95% CI = 95% confidence interval.

Table 2.

Methodologic Quality Assessment of the Interventional Studies

Criterion	Rosa et al., 2011[49]	Preshaw et al., 2005[48]
Randomization	No	No
Masked	Examiner mask	No
Examiner reliability	Yes (ICC for PD = 0.85; 95% CI 95% = 0.81 to 0.88)	No
Dropout rate (%)	44.09	46.94
Smoking-cessation rate (%)	20.40	18.27
Plaque scores (%) at 12 months	58.62 in quitters; 72.09 in non-quitters	69.7 in non-quitters; 60.5 in oscillators; 73.4 in quitters
Smoking-cessation compliance assessment	Expired-air carbon monoxide level	Salivary cotinine levels and expired-air carbon monoxide level
Statistical analysis	Per protocol	Per protocol
Follow-up	12 months	12 months

ICC = intraclass correlation coefficient; 95% CI = 95% confidence interval.

Table 3.

Main Characteristics and Results of Observational Studies

Reference	Study Characteristics and Outcomes				Main Results
	Sample	Examination Protocol	Outcome	Comparison Groups	
Bolin et al., 1993[46] Sweden	349 individuals (170 males and 179 females) with ≥20 remaining teeth	Radiographic bone loss in proximal sites	Ratio between bone height/root length	Smokers (n = 139), non-smokers (n = 157), quitters (n = 44), and new smokers (started smoking after baseline, n = 9)	1) Quitters presented significantly less radiographic bone loss height (4.4%) than smokers (6.0%, P <0.005). No significant differences between quitters and non-smokers were observed (4.4% versus 3.9%). 2) Individuals who started smoking after baseline had a radiographic bone loss of 5.2%. 3) Quitters had stopped smoking, on average, for 8.2 years.
Jansson and Lavstedt, 2002[47] Sweden	507 individuals (244 males and 263 females) with ≥5 remaining teeth	Radiographic bone loss in proximal sites	Ratio between bone height/root length and tooth loss	Smokers (n = 163), quitters (n = 124), and non-smokers (n = 220)	1) Quitters presented significantly less radiographic bone loss (0.09 mm) than smokers (0.13 mm, P = 0.017). 2) Smokers had higher tooth loss (3.7 teeth) than non-smokers and quitters (2.2 and 3.2 teeth, respectively), but the difference did not reach statistical significance.
Thomson et al., 2007[50] New Zealand	810 young individuals (399 females and 411 males)	Partial recording in the first evaluation (two quadrants, three sites per tooth) and full-mouth; six sites per tooth examination in the second.	CAL ≥3 mm	Smokers (n = 255), quitters (n = 69), former smokers at baseline (n = 72), and non-smokers (n = 414)	1) A total of 28.4% of the smokers were considered incident cases, whereas only 10.1% of the quitters were incident cases. Compared with never-smokers, smokers had a 5-fold higher chance (OR: 5.16; 95% CI: 2.73-9.76) of having CAL progression, whereas no increased likelihood was observed for quitters (OR = 1.47; 95% CI: 0.62-3.50).

OR = odds ratio; 95% CI: 95% confidence interval.

DISCUSSION

To the best of the authors' knowledge, this is the first systematic review evaluating the effect of smoking cessation on periodontal health. Only three epidemiologic[46,47,50] and two clinical studies[48,49] fulfilled the inclusion criteria. Epidemiologic studies showed a beneficial effect of smoking cessation on progression of CAL and radiographic bone loss. This positive effect could be identified as early as 6 years after smoking cessation in young individuals, and it was still evident 20 years after smoking cessation. The benefit of smoking cessation was evident for young and older adults. In addition, individuals who quit smoking while undergoing periodontal treatment had an added benefit as indicated by significantly shallower periodontal pockets than non-quitters and oscillators.

Only evidence derived from studies that prospectively followed up quitters was included in this review. Although this strategy yielded a limited number of publications, it ensured the inclusion of studies that more closely resemble the introduction of a smoking-cessation program for a cohort of smokers. Nevertheless, it is important to acknowledge that indirect evidence derived from cross-sectional[8,51-53] and longitudinal[6,33] studies supports the contention that smoking cessation has a positive effect on the periodontal status of former smokers.

No clinical studies evaluating the effect of smoking cessation alone on periodontal health were identified. Similarly, no studies compared a comprehensive smoking-cessation program with no intervention or a limited pharmacologic and/or behavioral intervention. Reasons for these omissions are probably related to the ethical dilemma of not providing the standard of care or best available treatment/intervention for periodontitis and smoking that would arise if such an analytical approach was implemented. The added effect of quitting smoking to periodontal therapy outcomes was indirectly evaluated by two small single-arm clinical studies that provided non-surgical periodontal treatment and smoking-cessation intervention to all individuals.[48,49] After 1 year of follow-up, response to periodontal treatment was compared among quitters, oscillators, and continuous smokers. The first study[11] showed a significantly greater periodontal pocket reduction for quitters than smokers, whereas the second failed to show significant differences. These results are difficult to interpret because of the small sample size (≈50), high dropout rate (≈45%), low smoking-cessation rate (≈20%), and low oral hygiene levels (≈60% plaque scores) for both studies. Nevertheless, it seems reasonable to conclude that at least a modest beneficial added effect of smoking cessation on periodontal treatment outcomes could be expected in the short term.

No specific data on reversal of risk for periodontitis after smoking cessation was found in the literature. Some clues on this issue may be derived from available longitudinal studies focusing on the effect of quitting smoking on tooth loss. Dietrich et al.[35] showed that quitters had a significantly lower risk for tooth loss compared with non-quitters. Risk for tooth loss decreased steadily with time, and after 10 years, the risk for quitters had approached that of never-smokers. Similar risk trends have been observed for cardiovascular disease and cancer, including head and neck cancer, with risk decreasing markedly within some years of smoking cessation; however, the risk only approaches that of never-smokers after 10 to 20 years of abstinence.[54,55] Although it is tempting to assume that the observed reduced risk for tooth loss might be related, at least in part, to improvements in periodontal health, it is important to acknowledge that tooth loss is a complex phenomenon that is heavily influenced by socioeconomic factors, access to dental care, and philosophy of treatment.[56] Nevertheless, it seems reasonable to assume that the risk for periodontitis could reduce markedly within a few years of smoking cessation and that a reversal of risk to never-smoker levels could be achieved in a decade.

Studies included in this review present important methodologic shortcomings. None of longitudinal studies used reliable methods to evaluate smoking-cessation compliance, such as saliva or expelled cotinine levels. Control of confounding variables, including sociodemographics, diabetes, and alcohol consumption, was not implemented by these studies. Moreover, the effects of dropout and non-response on these study results were not assessed. Although the true effect of these shortcomings is unknown, it is unlikely that they would invalidate the findings of the studies; future epidemiologic studies should strive to ascertain smoking status and minimize participation bias. Regarding the clinical studies, the high dropout rates, low smoking-cessation rates, and high plaque levels underscore the inherent difficulties related to this kind of study. The profile of smokers in smoking-cessation programs is very unstable, and depression is frequently observed among these patients.[57] Furthermore, patients who are not successful in quitting smoking are more likely to withdraw from the study, and the multiple time-consuming appointments for treatment and long-term follow-up are obstacles to maintain patients in the study. These factors might help explain

Table 4.

Main Characteristics and Results of Interventional Studies

Reference	Study Design, Sample Characteristics, and Outcomes				Main Results
	Sample	Intervention	Participants	Outcomes	
Preshaw et al., 2005[48] England	49 smokers (18 males and 31 females) with moderate to severe chronic periodontitis who wanted to quit smoking.	All individuals received non-surgical therapy in the first 3 months and smoking-cessation counseling throughout the study (including nicotine replacement and prescription of pharmaceuticals).	Participants were divided in three groups: 1) quitters, 2) oscillators, and 3) non-quitters.	CAL, PD, and radiographic evaluation.	1) Quitters were significantly more likely to have improvements in PD than non-quitters and oscillators. The percentage of sites with PD reduction ≥2 mm and ≥3 mm was, respectively, 28.5% and 11.5% for quitters, 18.0% and 5.2% for non-quitters, and 16.8% and 4.8% for oscillators. 2) No differences were observed regarding full-mouth mean CAL, PD, and radiographic parameters among groups.
Rosa et al., 2011[49] Brazil	52 smokers (20 males and 32 females) with severe chronic periodontitis who wanted to quit smoking.	Individuals received non-surgical therapy (four to six appointments with 7-day interval between them) and smoking-cessation therapy (including nicotine replacement and prescription of bupropion).	Participants were divided in three groups: 1) quitters, 2) oscillators, and 3) non-quitters. Most of the analyses were grouped non-quitters and oscillators.	CAL and PD	1) No significant differences were observed among groups regarding CAL, PD, and BOP: 2) Percentage of sites with PD reduction ≥2 mm and CAL gain ≥2 mm was, respectively, 14.0% and 14.7% for non-quiteers and oscillators and 10.4% and 15.8% for quitters.

the somewhat modest results observed in these studies.

CONCLUSIONS

Evidence regarding the effect of smoking cessation on periodontal health is very scarce, and this is a somewhat surprising finding given the wealth of studies supporting the negative effect, which should propel dental professionals to pursue a better understanding of the possible oral/periodontal benefits of smoking cessation. Nevertheless, smoking cessation seems to decrease the risk for incidence and progression of periodontitis, as well as to improve response to periodontal treatment. Additionally, indirect evidence suggests that a significant reversal of periodontitis risk might be achievable within 10 years after quitting smoking. Large, well-designed epidemiologic and clinical studies are needed to explore the potential benefits and, importantly, challenges associated with smoking-cessation programs in dental settings.

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