

# Periodontal disease in a group of Swedish adult snuff and cigarette users

Seppo Wickholm, Per-Östen Söder, Maria Rosaria Galanti, Birgitta Söder and Björn Klinge

Department of Periodontology, Institute of Odontology, Karolinska Institutet Huddinge, Sweden;  
Clinical Epidemiology Unit, Karolinska University Hospital, Stockholm, Sweden; Centre for Tobacco Prevention, Stockholm Centre of Public Health, Stockholm, Sweden

Wickholm S, Söder P-Ö, Galanti MR, Söder B, Klinge B. Periodontal disease in a group of Swedish adult snuff and cigarette users. *Acta Odontol Scand* 2004;62:333–338. Oslo. ISSN 0001-6357.

The aim of this study was to compare the prevalence of periodontal disease in different groups of tobacco users. Participants ( $n = 1674$ ) were selected from an initial random sample of residents in the Stockholm region. Socio-demographic characteristics and life-time history of tobacco use were registered in a self-completed questionnaire, followed by a clinical examination. Cumulative life-time tobacco use was analyzed in pack-years and can-years as the exposure of interest. Among participants, 50.8% were females and 49.2% were males. Life-time tobacco use was categorized into four mutually exclusive categories. Approximately, two-thirds of snuff users had combined snuff use with cigarette smoking during their life. Tobacco users had a higher prevalence of periodontal disease compared to never users. Exclusive smokers and mixed users presented the less favorable situation. Unhealthy periodontal conditions increased with increasing exposure to smoking, most evidently at the level of 15 or more pack-years. There was a significant positive association between current or former smoking and periodontal disease (OR = 2.7, CI = 1.7–4.3 and OR = 2.0, CI = 1.2–3.3, respectively) even after adjustment for plaque level. An indication of association was also apparent with former snuff use. Plaque was independently associated with periodontal disease, with a dose gradient. Smoking is associated with periodontal disease independently of plaque. Combining cigarette smoking and snuff use during life does not convey a decreased probability of being diagnosed with periodontal disease compared to smoking exclusively. □ *Dental; periodontitis; plaque; smokeless tobacco; smoking*

Seppo Wickholm, Department of Periodontology, Institute of Odontology, Karolinska Institutet and Centre for Tobacco Prevention, Stockholm Centre of Public Health, Stockholm, P.O. Box 4064, SE-14104 Huddinge, Sweden. Fax. +46 8 517 78 072, e-mail. seppo.wickholm@smd.sll.se

Cigarette smoking is associated with poor periodontal health, but the pathogenetic mechanisms remain to be clarified (1, 2). In a study by Grossi et al., smoking was significantly associated with bone loss and attachment loss (3). The role of dental plaque in periodontal disease is well established. Smoking is probably the single most significant risk factor for periodontal disease. Recent studies have concluded that smoking may have an effect *per se* on the development of periodontal disease, as measured by increased probing depth, loss of attachment, or bone loss (4–7). Smokeless tobacco is associated with different conditions, e.g. oral cancer, cardiovascular disease, and adverse pregnancy outcomes (8–10). However, there is little scientific evidence on the effects of smokeless tobacco, either exclusively or combined with smoking, on periodontal health, although it is reasonable to hypothesize that it could result in impaired periodontal health (1, 11). In Sweden, both cigarette smoking and the use of oral moist snuff (*snus*) have the same prevalence levels in the adult male population (12), while use of other varieties of smoked tobacco, such as cigar or pipe, is rare (13, 14).

Snuff (*snus*) consists of finely ground tobacco with high moisture (35–60%) and alkaline pH (7.8–8.5) (12, 15). The nicotine content ranges from 12.4 to 15.1 mg/g dry weight (15). Combined use of both cigarettes and snuff, either simultaneously or alternately over time, has been reported (16). It is interesting to note that a recent study reported

13.8% of boys in the ninth grade in the Stockholm area of Sweden combined the use of cigarettes and snuff (17).

The aim of this epidemiological investigation was to compare the prevalence of periodontal disease in tobacco users who consume either cigarettes or snuff, and those who use both products.

## Materials and methods

An initial sample of 3273 subjects was randomly selected from the registry file of all inhabitants in the Stockholm region who were born on the 20th of any month from 1945 to 1954 and were between 31 and 40 years of age at the time of the study. Those who were selected were informed about the purpose of the study and invited to undergo a clinical investigation. The invitation was accepted by 1674 individuals. Among the participants, 50.8% (851) were females, with a mean age of 36.7 ( $\pm 2.9$  s), while 49.2% (823) were males, with a mean age of 36.7 ( $\pm 2.8$  s). Informed consent was obtained from all participants before enrolment in the study and the study was approved by the Ethics Committee at Huddinge University Hospital, Huddinge, Sweden. All subjects were required to answer a questionnaire, which included questions concerning their current and past tobacco use. Subjects reporting any tobacco use in their life were

defined as life-time tobacco users. Subjects reporting any tobacco use at the time of the study were defined as current users. Exclusive smokers we defined as subjects reporting only life-time cigarette smoking and exclusive snuff users those only reporting life-time use of snuff. Mixed users were subjects who reported both snuff use and cigarette smoking during their life time. Cumulative life-time cigarette smoking was quantified by pack-years (amount of cigarettes smoked per day, divided by 20 and multiplied by years of smoking). Cumulative life-time snuff use was quantified in analogy by can-years (average number of cans consumed in a week multiplied by years of use). The combined use of cigarettes and snuff among those subjects who used both products any time in life was expressed separately in pack-years and can-years. As the distribution of these categories of cumulative exposure was skewed towards low values, we analyzed the data both as a continuous variable and according to the following 'a priori' categories: 0–0.1, 0.1–2.5, 2.6–9, 10–14, 15 or more pack-years.

The clinical investigation included an assessment of the following outcome measures: Plaque index (PI I) was measured according to Silness & Loe (1964). The score ranged from 0 (tooth surface clean) to 3 (abundant plaque) (18). Gingival index (GI) was measured according to Loe & Silness (1963), with score ranging from 0 (gingival unit healthy) to 3 (ulcerating or spontaneous bleeding) (19). Amount of calculus was determined through the Calculus index simplified (CI) according to Greene & Vermillion (1964). Score 0 representing absence of calculus and score 3 indicating the most severe situation (20). Number of teeth with pocket depth (PD)  $\geq 5$  mm and gingival recessions (yes/no) were also registered. Pocket depth was measured with a Hu-Friedy (PCPUNC 15) periodontal probe (Hu-friedy, Chicago, Ill., USA). All examinations were performed by 6 periodontists in 15 community dental centers. The pre-study calibration included six sessions of common registrations of the parameters to be used (21).

#### Data analysis

The univariate analysis of categorical data compared the prevalence of odontological outcomes among categories of tobacco users. The departure from the expected distribution was tested by means of the chi-square statistic. A *P* value below 0.05 was chosen to determine the statistical significance.

By means of logistic regression (22) we further analyzed the cross-sectional association between periodontitis as dichotomous outcome (presence of 3 or more teeth, with PD  $\geq 5$  mm) and tobacco use, after adjustment for potential confounders, such as sex (male–females), age, and education ( $\leq 9$  years or  $>9$  years of education). As a measure of association we calculated the odds ratios (OR), while the corresponding 95% confidence limits (CL) were used to estimate precision. The CL also gave information on the departure of the point estimate (the OR) from the

Table 1. Life-time patterns of tobacco use in the study population (*n* = 1674)

Tobacco use	Females		Males		All	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Life-time use						
Never users	299	35.1	250	30.4	549	32.8
Ever smokers	540	63.5	432	52.5	972	58.1
Ever snuff users	3	0.3	51	6.2	54	3.2
Ever mixed users	9	1.0	90	10.9	99	5.9
Total	851	100.0	823	100.0	1674	100.0

reference value of 1, expected under the null hypothesis of no association.

Maximum likelihood equations were used to derive the model parameters and their standard errors. All analyses were conducted using SAS software (SAS 8.02, SAS Institute Inc., Cary, N.C., USA).

## Results

Table 1 gives the life-time tobacco use in the study population according to four mutually exclusive categories, while current tobacco use according to the same categories is displayed in Table 2. The prevalence of current smoking (including current mixed use) was almost equal between women and men, while the prevalence of current snuff use was 10 times higher among men than among women. Forty-two percent of current smokers and 18.2% of the former smokers had smoked 15 pack-years or more. Seventy-eight percent of current snuff users and 60% of former snuff users had used 5 can-years or more.

The prevalence of smokers was higher among those with compulsory school education only (52.7%), compared to those with a higher level of education (34.6%) (*P* < 0.001).

Outcome measures of periodontal disease according to life-time tobacco use are given in Table 3. Cut-point levels for outcome measures were PI I  $\geq 2.0$ , GI  $\geq 2.0$ , CI  $\geq 2.0$  and three teeth or more with PD  $\geq 5$  mm (6, 13). All categories of tobacco users had a higher prevalence of each outcome measure of periodontal disease compared to never users. The highest prevalence was seen among

Table 2. Current patterns of tobacco use in the study population (*n* = 1674)

Tobacco use	Females		Males		All	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Current use						
No current use	509	59.8	434	52.7	943	56.3
Current smoker	331	38.9	278	33.8	609	36.4
Current snuff use	7	0.8	75	9.1	82	4.9
Current mixed use	4	0.5	36	4.4	40	2.4
Total	851	100.0	823	100.0	1674	100.0

Table 3. Prevalence (%) of subjects with Plaque index  $\geq 2.0$  (PI I), Gingival index  $\geq 2.0$  (GI), Calculus index  $\geq 2.0$  (CI), Gingival recessions and with 3 teeth or more with pockets  $\geq 5$  mm (PD), according to tobacco use

Life-time tobacco use	<i>n</i>	PI I $\geq 2.0$ %	GI $\geq 2.0$ %	CI $\geq 2.0$ %	Recessions %	PD $\geq 5$ mm %
Never users	549	1.64	6.56	1.64	54.28	4.74
Ever smokers	972	2.27	15.02	5.06	63.09	12.14
Ever snuff users	54	1.85	7.41	5.56	62.96	7.41
Ever mixed users	99	3.03	9.09	6.06	65.31	12.12
Column <i>P</i> value		NS	$P < 0.001$	$P < 0.01$	$P < 0.01$	$P < 0.001$

exclusive smokers and among those who had combined snuff use with smoking. The proportions of subjects with three teeth or more with PD  $\geq 5$  mm was similar between mixed users and exclusive smokers. However, in general the proportions were significantly different for GI, PD  $\geq 5$  mm ( $P < 0.001$ ), CI, and gingival recessions ( $P < 0.01$ ), but not for PI I. The results were almost identical when current use was analyzed (data not shown).

The proportion of participants with three or more teeth with PD  $\geq 5$  mm in relation to pack-years of smoking is shown in Fig. 1. The proportion of individuals with unhealthy periodontal conditions increased with increasing exposure, the difference being conspicuous at a level of 15 or more pack-years. Among snuff users there was no difference in the prevalence of PD  $\geq 5$  mm through categories of increasing exposure. Among mixed users, those who started tobacco use with cigarette smoking constituted the most numerous subgroup ( $n = 56$ ). Sixteen percent of these subjects had three or more teeth with PD  $\geq 5$  mm, while the proportions were 10% among those who began with both products simultaneously ( $n = 20$ ) and

7% among those who started with snuff ( $n = 15$ ). Subjects who started with smoking also had a higher cumulative exposure to smoking compared with the other subgroups (data not shown). Table 4 reports the odds ratio (OR) of periodontal disease, defined as the presence of three or more teeth with PD  $\geq 5$  mm, according to tobacco use and PI I. There was a significant positive association between both current and former smokers and periodontal disease compared to never smoking. The OR increased by 6% for each additional pack-year. The association between snuff use and periodontal disease was not statistically significant, although there was an indication of an association with former snuff use compared to never use. There was no hint of increasing risk with increasing exposure (can-years). However, it should be noted that only 8% of the sample had an exposure index above zero. Plaque was independently associated with periodontal disease at all levels, with a dose gradient. Compared to a PI I of  $<1$ , a PI I of 1–2 was associated with a 2.7 and for a PI I  $>2$ , 4.8 times higher probability of being diagnosed with periodontal disease. These associations remained almost unchanged

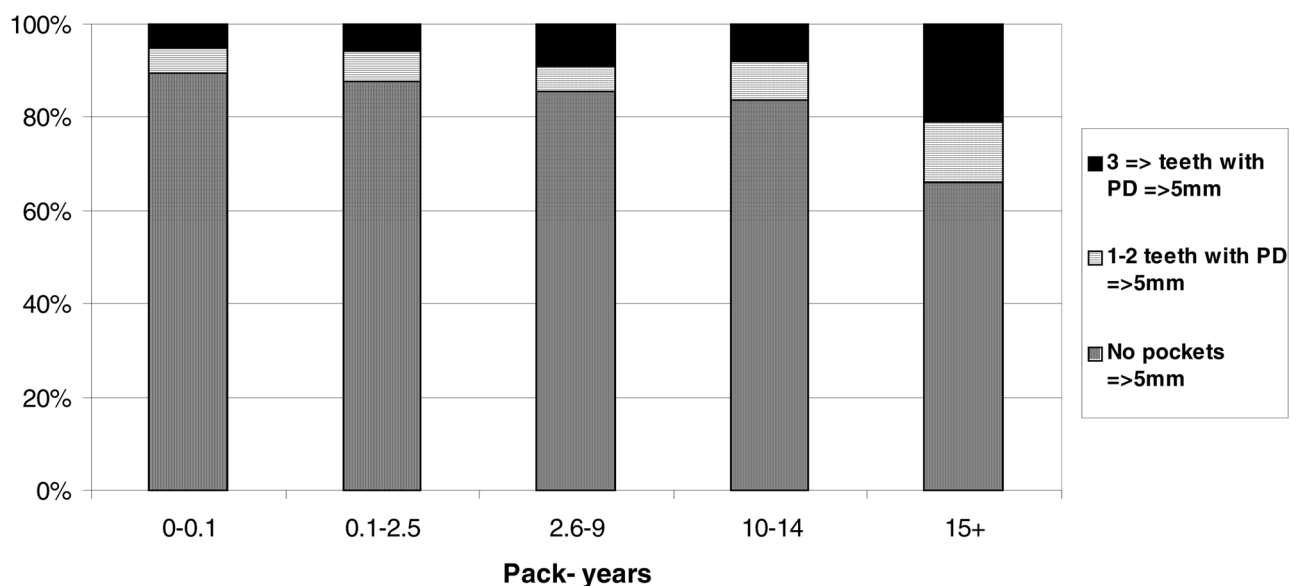


Fig. 1. Proportions of subjects with no teeth with pockets  $\geq 5$  mm, 1–2 teeth with PD  $\geq 5$  mm, or 3 teeth or more with PD  $\geq 5$  mm, respectively, in relation to smoking exposure expressed in pack-years.

after further mutual adjustment for plaque level, smoking, and snuff use.

## Discussion

Smoking is strongly associated with various forms of adverse health effects. Cancer, cardiovascular disease (23), and periodontal disease have major impacts on public health (6, 14, 24, 25). From our study, it appears that a smoking exposure of 15 pack-years or more represents the level at which the prevalence and development of periodontal disease becomes mostly evident, even if the prevalence itself probably increases continuously with increasing exposure. Many smoking related outcomes, such as lung diseases and cardiovascular diseases, present a similar pattern of occurrence (23). Our findings confirm earlier reports on periodontal disease (26, 27) but also show that smoking affects periodontal disease at a relatively young age.

There are few studies on the use of snuff and periodontal health (11). Owing to the relative rarity of smokeless tobacco use in most developed countries, in periodontal research it is customary to categorize tobacco use with regard to cigarette smoking (4, 14). The Swedish population, in which one out of five men uses snuff, offers a more complex picture of tobacco use than most developed populations, thus allowing more refined analysis of the health effects of smoking and smokeless tobacco use. The mixed use of cigarettes and smokeless tobacco renders the analysis of separate effects more complicated (28, 29). Over time, subjects may change their patterns of tobacco use, and switch from one tobacco product to another, quit or relapse (30). In this study we constructed mutually exclusive groups of life-time tobacco use. In addition, we

studied both life-time and current tobacco use and were able to devise cumulative indexes of exposure to tobacco products. Since periodontal disease probably develops after years of exposure it is indeed important to be able to quantify the total exposure to tobacco products during a lifetime (26, 31–33). In this study, current use of snuff was not significantly associated with periodontitis. In contrast to a study among young adults (11), we found that former use of snuff, but not current use, was associated with the development of periodontal disease. Taken together, these findings indicate that any potential association between snuff use and oral diseases would be difficult to detect in a cross-sectional study like the present one, and for several reasons. First, the adverse effect of snuff use on periodontal diseases may require prolonged exposure to manifest itself, and this would not likely be achieved in such a young population. Second, persistent users may represent a selected group with lower background risk of periodontal diseases. This would be the case if the presence of oral diseases preceded and motivated the cessation of tobacco use, as seems likely given the positive association of periodontal disease among former users of snuff in this study. A similar effect, due to selection, was also observed in a study of oral cancer (34). Studies have found that smoking is associated with several measures of periodontal damage, but reports have been contradictory (24, 25, 31, 35). We observed a gradient in the prevalence of most indicators of periodontal disease from never users of tobacco, who had the most favorable clinical picture, to cigarette smokers (exclusively or in combination with snuff) presenting the least favorable situation. Ever snuff users had a higher prevalence of calculus, gingival inflammation, gingival recessions and teeth with PD  $\geq 5$  mm than never users of tobacco, even if the association with periodontitis was not apparent in regression analysis.

Table 4. Risk of periodontal disease (three or more teeth with pocket depth  $\geq 5$  mm) associated with tobacco use and plaque level. Odds ratio (OR) and corresponding 95% confidence interval (multivariate analysis)

Risk indicator	<i>n</i>	Model 1		Model 2		Model 3	
		OR*	CI = 95%	OR†	CI = 95%	OR‡	CI = 95%
Smoking							
Never	603	ref		ref			
Former	422	1.97	(1.19–3.32)	2.04	(1.22–3.43)		
Current	649	2.71	(1.74–4.34)	2.41	(1.53–3.88)		
Pack-years (continuous)		1.06	(1.04–1.08)	1.06	(1.04–1.08)		
Snuff use							
No use	1521	ref					
Former use	31	2.25	(0.71–5.95)			2.55	(0.80–6.80)
Current use	122	0.71	(0.32–1.41)			0.66	(0.30–1.32)
Can-years (continuous)		1.00	(0.98–1.01)			1.00	(0.98–1.01)
Plaque index							
<1	1146	ref					
1–2	488	2.72	(1.89–3.92)	2.50	(1.72–3.63)	2.73	(1.89–3.96)
>2	35	4.81	(1.99–10.80)	4.70	(1.92–10.66)	4.63	(1.91–10.43)

\* Adjusted for gender, age (continuous) and education (categories).

† As model one with further mutual adjustment for snuff use and/or plaque.

‡ As model one with further mutual adjustment for smoking and/or plaque.

However, there were very few exclusive users of snuff in this sample; therefore the study had very low statistical power to detect a weak association. The higher proportion of snuff users with gingival recessions is in accordance with another Swedish study (36). It is of interest to note that smokers and mixed users had the same proportions of individuals with PD  $\geq 5$  mm in three or more teeth. In addition, mixed users who started tobacco use with smoking, or with both products at the same age, did not show significant difference in their periodontal status compared to exclusive smokers, despite the heavier exposure to smoking among the latter. Previous analyses did not report on this aspect, which deserves to be further explored in longitudinal studies. In fact, it might indicate that switching from smoking to snuff might be a worthless effort to prevent disease onset or progression. An additional finding in this study was the apparently independent association of periodontitis with PI I, on the one side, with smoking on the other. The positive association of periodontitis with dental plaque, also showed a remarkable dose-response effect and is in accordance with other studies (5, 6, 26, 37). A major limitation of our study is the cross-sectional design that makes it impossible to observe the time course of the events, hence it is difficult to infer causal relations. Self-selection of participants in the study, selection of healthier tobacco users, and a certain degree of misclassification of exposure cannot be ruled out, and may have biased the estimates of an association downwards. In our opinion the strength of the present study are: 1. The prevalence of tobacco use in this sample reflected quite closely the national surveys at the time of the study. Contrary to the majority of previous studies, this investigation was based on a population sample rather than on a clinical one. This fact allowed the inclusion of pathological conditions at the less severe end of the spectrum and prevented the selection of subjects seeking care for clinically evident disease. Even if the investigators could not be blinded as to the exposure status of the study subjects, the clinical examination was carried out in a standardized way by experienced dentists. Therefore major observer bias can be excluded. The randomized sample representing more than 90.000 inhabitants of the Stockholm area. 2. The dividing up of the sample in categories depending tobacco habit and current and lifetime exposure to tobacco. Last, but not least, the compilation of a detailed history of tobacco use allowed the analysis of both quantitative and qualitative aspects of exposure. The data and results from the present study represent a valuable baseline for future prospective studies in this cohort.

In summary, smoking, independently of plaque, is associated with periodontal disease in a dose-dependent fashion. The amount of plaque, however, is associated with periodontal disease independently of tobacco use. Combining cigarettes and snuff does not convey a decreased probability of being diagnosed with periodontal disease compared to exclusive smoking. Longitudinal studies with extended follow-up should be conducted to

provide a better understanding of the consequences of snuff use and the time-course of tobacco-induced periodontal disease.

*Acknowledgements.*—The study was supported by Karolinska Institutet, Stockholm, Centre of Public Health, Centre for Tobacco Prevention, DFS, Department of Health and Welfare, grant F 84/189 and Pfizer Consumer Health unrestricted grant.

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Received for publication 12 July 2004

Accepted 5 November 2004