

Periodontal disease in relation to smoking and the use of Swedish snus: epidemiological studies covering 20 years (1983–2003)

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Abstract

Aim: The aim of the present study was to examine how deleterious current smoking and the use of Swedish moist snuff (snus) is for periodontal health compared with non-tobacco users.

Materials and Methods: The studies comprised three epidemiological cross-sectional studies, in 1983, 1993 and 2003, of stratified random samples aged 20, 30, 40, 50, 60 and 70 years. The numbers of dentate participants were 550, 552 and 523, respectively. The participants were examined clinically and radiographically.

Diagnostic criteria were the number of teeth, plaque, gingival status, probing pocket depth (PPD) ≥ 4 mm, height of the alveolar bone level and classification by periodontal disease experience. In addition, participants were asked about their tobacco habits.

Results: Multiple logistic regression shows, after adjusting for age, gender and sociodemographic variables, that relative to non-tobacco users, cigarette smokers had statistically significant less gingivitis, a higher frequency of PPD ≥ 4 mm and a higher incidence of severe periodontitis. There was no significant association between gingivitis, frequency of PPD ≥ 4 mm and periodontal disease experience and snus use.

Conclusions: Cigarette smokers were found to have a statistically significant higher risk of severe periodontitis than non-tobacco users and users of snus. Using snus did not seem to be a risk factor for periodontitis.

Key words: epidemiology; moist snuff; periodontal disease; periodontitis; smokeless tobacco; smoking; snus; tobacco

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Periodontitis is an infectious disease characterized by inflammation and loss of supporting tissues around the teeth. Over several decades, many cross-sectional and longitudinal epidemiological studies on the prevalence and severity of periodontal disease have been performed and it has been shown that

only a minority of a population is likely to develop severe loss of periodontal attachment (Hugoson & Jordan 1982, Löe et al. 1986, Miller et al. 1987, Baelum et al. 1988, Papapanou et al. 1988, Yoneyama et al. 1988). The fact that some individuals are more prone to periodontitis than others has triggered an increasing interest in identifying individuals at risk and the risk factors that influence susceptibility to the onset and development of periodontal disease (Johnson et al. 1988, Albandar et al. 2000).

The relationship between smoking and periodontal disease is well documented and has been reported in a large

number of studies of varying designs, both epidemiological and clinical. Thomson et al. (2007) have demonstrated, in a prospective study among young adults, that current and long-term smoking is detrimental to periodontal health. Among young adults, Rosa et al. (2008) demonstrated that the mean plaque and gingival indices, like clinical attachment level and sites with recession, were significantly greater in smokers than in those who had never smoked. In older subjects, studies report that smoking is a risk factor for tooth loss, probing attachment loss and alveolar bone loss (Axelsson et al. 1998, Norderyd et al. 1999, Johnson & Hill

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2004, Pihlstrom et al. 2005, Jansson & Lagervall 2008). A 10-year prospective study of tobacco smoking and periodontal health by Bergström et al. (2000) showed that periodontal health is compromised by daily smoking, as evidenced by an increase in periodontally diseased sites in smokers compared with former smokers and non-smokers, whose periodontal condition remained unaltered throughout the study period.

Swedish nicotine-containing smokeless tobacco (there are many different brands on the market) is different from smokeless tobacco in other countries (Idris et al. 1998) and is called snus. Thus, snus products generally contain small amounts of fermentable carbohydrates and have a high pH value and a low level of tobacco-specific nitrosamines (TSNA) (Lee 2011, Foulds et al. 2003). There is ample documentation of oral mucosal changes due to the use of snus (Axell et al. 1976, Mørne et al. 2002, Taybos 2003, Rolandsson et al. 2005). Gingival recessions and loss of periodontal attachment occur largely in connection with mucosal lesions caused by smokeless tobacco/snus (Robertson et al. 1990, Hart et al. 1995, Rolandsson et al. 2005, Montén et al. 2006); however, few studies have investigated the potentially harmful effects of smokeless tobacco/snus on periodontal conditions. These few studies have been conducted in young adults with short-term use (Little et al. 1992, Montén et al. 2006) and in special groups, such as baseball players (Ernster et al. 1990) or employees in the submarine service of the Swedish navy (Bergström et al. 2006). Regarding the prevalence of plaque and gingivitis, no significant differences have been shown between non-tobacco users and smokeless tobacco/snus users (Robertson et al. 1997, Rolandsson et al. 2005, Montén et al. 2006), nor is the use of snus associated with the presence of periodontal bone loss (Bergström et al. 2006).

Considering the strong evidence showing tobacco in the form of smoking as a major risk factor for periodontitis, it is important to investigate the possible risk associated with the use of snus (Bergström 2004); however, as yet, there has been no study investigating the effects of cigarette smoking and the use of smokeless tobacco/snus in the same adult population. The aim of the present study was to examine how deleterious the current smoking and use of Swedish snus is for periodontal health compared with non-users.

Materials and Methods

The sample in this study consisted of three cohorts in the city of Jönköping, Sweden. In 1983, a stratified random sample of individuals in Jönköping was invited to take part in a dental health examination. In 1993 and 2003, new samples of subjects from the same city were selected. Each sample consisted of 130 randomly selected individuals who turned 20, 30, 40, 50, 60 and 70 in these years. Of these, 550, 552 and 523 dentate individuals attended the 1983, 1993 and 2003 examinations, respectively (Hugoson et al. 2005a,b). Everyone selected for the study was sent a written invitation to take part in a dental health examination. They were informed of the purpose of the investigation and that a clinical and radiographic examination of the teeth and jaws would be performed.

Non-respondents

The numbers of non-respondents in 1983 and 1993 were similar, while the number of non-respondents in 2003 was somewhat higher. In 2003, 26–36% of those selected in each age group declined to participate for various reasons. Detailed information about the number of non-respondents and the reasons for not taking part in 1983, 1993 and 2003 is published elsewhere (Hugoson et al. 2005b).

Questionnaire

A questionnaire was completed in conjunction with the oral health examination. Among other factors, the questionnaire collected sociodemographic data, but also included questions relating to medical and oral health history as well as dental and tobacco habits. Occupational status was divided into employed (blue- and white-collar workers) and not employed (student, unemployed, pensioners and housewife/househusband). Educational level was described as low education (9-year compulsory school, practical upper secondary school) or higher education (upper secondary school, college of higher education). Marital status has been listed as single or partner.

Respondents were asked to detail their tobacco habits (cigarette smoking and use of snus) and these were verified during the clinical examination; they refer to the time of examination. Current

smokers and snus users were defined as daily smokers (number of cigarettes per day noted) and daily snus users (number of boxes per day). Pipe or cigar tobacco was recalculated as a number of cigarettes. Non-tobacco users did not use tobacco in any form. In 1993, data on former smokers (105 participants) were collected. The same basic information on the use of tobacco was collected in each examination year. Among the participants, there were 34 dentate mixed tobacco users e.g., they both smoked and used snus. These individuals were excluded from the analyses. The final population in this study was therefore 539, 543 and 509 non-tobacco users, smokers and snus users in 1983, 1993 and 2003, respectively, in total 1591 individuals (Table 1).

Clinical examination

The clinical examinations were carried out in each year by six calibrated dentists in dental offices with excellent equipment and optimal lighting. Each clinical and radiographic examination required 60–90 min.

Diagnostic criteria

Prevalence of edentulous individuals and number of existing teeth

The number of edentulous individuals and number of existing teeth were recorded. Third molars were excluded from the analysis.

Plaque index (PLI)

The presence of visible plaque was recorded for four tooth surfaces after drying with air according to the criteria for PLI 2 and 3 (Löe 1967).

Gingival status

The presence of gingival inflammation corresponding to gingival indices (GI) 2 and 3 was recorded for four tooth surfaces. Gingival inflammation was recorded if the gingiva bled on gentle probing (Löe 1967).

Probing pocket depth (PPD)

Pocket depth was recorded in millimetres and probing pocket depth (PPD) ≥ 4 mm was registered. The periodontal probe designed by Hilming was used in all studies.

Table 1. Number of dentate non-tobacco users, smokers and snus users in different age groups in 1983, 1993 and 2003

Age group	Non-tobacco users			Smokers			Snus users		
	total	male	female	total	male	female	total	male	female
1983									
20	49	21	28	38	11	27	10	10	0
30	54	25	29	34	17	17	7	7	0
40	72	33	39	23	10	13	3	3	0
50	67	27	40	28	12	16	0	0	0
60	58	27	31	24	17	7	1	1	0
70	58	28	30	12	8	4	1	1	0
Total	358	161	197	159	75	84	22	22	0
1993									
20	68	28	40	17	7	10	11	11	0
30	67	41	26	19	8	11	15	13	2
40	59	33	26	26	14	12	6	6	0
50	71	32	39	23	10	13	2	2	0
60	71	38	33	10	6	4	2	2	0
70	66	23	43	8	1	7	2	2	0
Total	402	195	207	103	46	57	38	36	2
2003									
20	52	24	28	19	9	10	9	9	0
30	68	27	41	12	3	9	11	11	0
40	55	27	28	14	9	5	9	7	2
50	64	25	39	17	7	10	9	8	1
60	64	31	33	14	5	9	4	4	0
70	79	36	43	7	2	5	2	2	0
Total	382	170	212	83	35	48	44	41	3

Gingival recession (GR)

The prevalence of exposed root surfaces apical to the cemento-enamel junction or crown margin was registered for four tooth surfaces.

Supragingival calculus

The presence of supragingival calculus was recorded for each tooth after drying with air and the number of teeth with supragingival calculus was recorded.

Radiographic examination

The radiographic examination was carried out using both extra- and intra-oral radiographs. All radiographic examinations were performed with a lead apron covering the subject. If a participant had recently had a radiographic examination, those radiographs were obtained from the participant's dentist. When necessary, the intra-oral examination was supplemented with separate radiographs. Owing to improved oral health and ethical considerations, the radiographic examination was somewhat changed over the course of the studies.

Thus, in 1983, all age groups underwent a full-mouth intra-oral examination consisting of 16 periapical and four posterior bite-wing radiographs. The

1983 examination also included panoramic radiographs. In 1993, the radiographic examination of the 20- and 30-year age groups comprised six bite-wing radiographs (two in the frontal region and four in the posterior region) and panoramic radiographs. The 40–70-year age groups had a full-mouth intra-oral examination and panoramic radiographs. However, in 2003, radiograph examination of the 20–40-year age groups comprised six bite-wing radiographs (two in the frontal region and four in the posterior region) and panoramic radiographs. The 50–70-year age groups had a full-mouth, intra-oral radiographic examination and panoramic radiographs. Where deep caries and root-filled teeth were visible in the panoramic radiographs of the 20–40-year-olds, a periapical radiographic examination was conducted.

Intra-oral radiographs were mounted in frames or masked and subsequently studied using a pair of observation binoculars in accordance with Mattsson (1953).

Classification according to the severity of the periodontal disease experience

All dentate individuals were classified according to clinical and radiographic findings, as proposed by Hugoson and Jordan (1982), where “around most

teeth” (Groups 3, 4 and 5) signifies 80–100% of the teeth:

Group 1: Healthy or almost healthy gingival units and normal alveolar bone height; <12 bleeding gingival units in the molar-premolar regions.

Group 2: Gingivitis; ≥12 bleeding gingival units in the molar and premolar regions; normal alveolar bone height.

Group 3: Alveolar bone loss around most teeth not exceeding 1/3 of the length of the roots.

Group 4: Alveolar bone loss around most teeth ranging between 1/3 and two-third of the length of the roots.

Group 5: Alveolar bone loss around most teeth exceeding 2/3 of the length of the roots; presence of angular bony defects, furcation defects or both.

Bone level index (BLI)

Proximal bone level was calculated as a percentage of the total length of the tooth (Björn et al. 1969). Periodontal bone level in the pre-molar and molar regions of the lower jaw was chosen as being representative of the entire dentition (Björn 1974). Bone level was recorded mesially and distally for each molar and pre-molar tooth in the lower jaw. The mean value of these measurements (BLI) was calculated for each individual.

Subgingival calculus

The dentition was divided into sextants, delimited by the canines in each jaw. Subgingival calculus visible inter-proximally was recorded. A sextant was recorded as having calculus when inter-proximal calculus was visible on at least one tooth surface.

Measures of PLI, GI, PPD ≥ 4 mm and GR were expressed as the individual's percentages of the total number of tooth surfaces or sites (PLI%, GI%, PPD% and GR%). The prevalence of sextants with subgingival calculus was expressed as a percentage of the total number of sextants.

Data processing and statistical analysis

Statistical analysis

The data were described by means of ordinary descriptive statistics and analysed using the Statistical Package for Social Sciences (SPSS). ANOVA was used to study the differences between non-

tobacco users, smokers and snus users, including the *post hoc* test according to Sheffé. ANOVA was also used when studying differences over time. To determine whether there were any differences in the proportion of participants with severe periodontal disease between the different groups of non-tobacco users or smokers, the differences between proportions were analysed by means of a binomial test with the inclusion of continuity correction. The analyses were used for each examination year, 1983, 1993 and 2003.

There were no statistically significant differences between non-smokers and former smokers as regards BLI ($p = 0.19$) in 1993. Former smokers were therefore included with non-tobacco users in the analyses. In 1983 and 2003, no information about former smokers was collected.

Multivariable logistic regressions were used in some analyses and odds ratios (OR) were calculated. For the logistic regression analysis, GI, PPD ≥ 4 mm, BLI as well as periodontal disease experience were dichotomized when used as outcome variables; $<20\%$ versus $\geq 20\%$ of tooth surfaces with gingivitis, $<10\%$ versus $\geq 10\%$ sites with PPD ≥ 4 mm, $\geq 60\%$ versus $<60\%$ bone level and periodontal disease experience Groups 1–3 versus Groups 4 and 5, respectively (Hugoson et al. 1992). The hypothesis to be tested were, after adjusting for co-factors, that there was no differences between non-users and smokers as well as between non-users and snus users as regards gingivitis, PPD ≥ 4 mm, BLI and periodontal disease experience.

The explanatory variables taken from the questionnaire were age, gender, socio-demographic status and tobacco use (smoking yes/no and use of snus yes/no) and PLI%, supra- and subgingival calculus from the clinical examinations. The significance was set as $p < 0.05$.

Ethical considerations

Throughout the study, the ethical rules for research described in the Helsinki Declaration 1964 were followed. The Ethics Committee at Linköping University, Linköping, Sweden, approved the 2003 study (reference no. 02-376).

Results

Approximately 90% of the individuals in all age groups in all studies were Caucasian and born in Sweden.

The total numbers of non-tobacco users, smokers and snus users were 1142 (526 males and 616 females), 345 (156 males and 189 females) and 104 (99 males and 5 females), respectively. The distribution of dentate non-users, smokers and snus users in 1983, 1993 and 2003, divided into age groups and males and females, is given in Table 1

The non-tobacco users were statistically significantly older (mean 45.9, SD 16.9, 95% CI = 44.9–46.9) than both smokers (mean 40.9, SD 15.8, 95% CI = 39.3–42.6) and users of snus (mean 34.9, SD 14.3, 95% CI = 32.1–37.7). Smokers were significantly older than snus users. There was no statistically significant difference in gender between non-tobacco users and smokers, but there was a statistical difference in gender between non-tobacco users and snus users, as well as between smokers and snus users, with more males among snus users.

Among smokers, the percentage of individuals smoking 1–5, 6–9 or ≥ 10 cigarettes per day in 1983 was 28%, 10% and 62%, respectively. The corresponding figures were 20%, 12% and 68% in 1993 and 29%, 10% and 61% in 2003. Of the participants smoking 1–5, 6–9 or ≥ 10 cigarettes per day, 9%, 23% and 24%, respectively, were in periodontal disease Groups 4 and 5 (Table 3). The number of boxes of snus varied between 2 and 4 boxes/week (mean = 3.4 boxes).

The mean values, 95% confidence intervals and p -values for non-tobacco users, smokers and snus users for the variables studied (number of teeth, PLI, GI, GR, PPD, BLI, supra- and subgingival calculus) are given for each examination year in Table 2.

In 1983, non-users as well as smokers had statistically significant fewer mean number of teeth than snus users ($p = 0.010$ and $p = 0.016$, respectively). In 1993, there was no statistically significant difference in the number of teeth between non-users, smokers and snus users. Non-users had statistically significantly more teeth in 2003 compared with 1983 ($p < 0.001$) and non-users and snus users had significantly more teeth than smokers ($p < 0.001$).

Regarding PLI and GI, there were no statistically significant differences between non-users, smokers or snus users either in 1983 or in 2003. However, there were statistically significantly lower mean PLI and GI values

for non-users in 2003 compared with PLI in 1983 and 1993 ($p < 0.001$) and for snus users compared with 1993 ($p = 0.002$). There was no significant difference over time for smokers.

Regarding PPD, smokers had a higher frequency of PPD ≥ 4 mm in all the examination years, which also reached a statistically significant level compared with non-users in 1983 and 2003 ($p = 0.001$) and compared with snus users in 2003 ($p = 0.001$).

The mean BLI was higher among snus users compared with both non-users and smokers in all the examination years and reach a statistically significant level both in 1983 and in 2003. Between non-users and smokers, there were only minor differences in the mean BLI in 1983 and 1993 but these had reached statistical significance in 2003 ($p = 0.018$). Regarding GR, there were only minor differences between non-users, smokers and snus users in the different examination years.

For supra- and subgingival calculus, there were no significant differences between non-users, smokers and snus users in the different examination years, apart from supragingival calculus in 2003, where non-users and snus users had statistically significantly fewer teeth with calculus than smokers ($p < 0.001$).

The frequency (%) distribution of individuals according to the severity of periodontal disease experience (Groups 1, 2, 3, 4 and 5) is given for non-tobacco users, smokers and snus users in Table 3. In 1983 and 2003, statistically significantly more smokers were in Groups 4 and 5 compared with non-tobacco users ($p = 0.02$ and $p < 0.001$, respectively). Among snus users, none of them were found in Groups 4 and 5 in 1983 or in Group 5 in any of the examination years. In 2003, there were statistically significantly fewer non-users in Groups 4 and 5 compared with 1993 ($p = 0.03$). Among smokers and snus users, there were no significant differences over time.

Multivariate regression analyses

The results from the multiple logistic regressions show that, after adjusting for age, gender and sociodemographic variables, there were small variations in the association between the outcome variable GI and the explanatory variables and the different examination years. In 1983, 1993 and 2003, there was a statistically significant association between

Table 2. Number of individuals examined, mean values, 95% CI and *p*-values for non-tobacco users, smokers and snus users and for the different variables studied in 1983, 1993 and 2003

	1983			1993			2003		
	<i>n</i>	mean	<i>p</i> -value	<i>n</i>	mean	<i>p</i> -value	<i>n</i>	mean	<i>p</i> -value
Number of teeth									
Non-user	358	23.0 ± 0.6	<i>0.010</i>	402	24.5 ± 0.5		382	25.4 ± 0.4	0.001
Smoker	159	23.1 ± 1.0	0.016	103	24.0 ± 1.2		83	23.3 ± 1.4	0.001
Snus user	22	27.1 ± 0.7		38	26.0 ± 1.3		44	26.8 ± 0.6	
PLI (% sites)									
Non-user	358	31.3 ± 3.0		402	32.7 ± 2.4		382	18.3 ± 2.0	0.053
Smoker	159	33.8 ± 4.3		103	33.6 ± 4.8		83	24.4 ± 5.5	
Snus user	22	31.2 ± 11.6		38	35.8 ± 8.4		44	17.1 ± 6.0	
GI (% sites)									
Non-user	358	27.0 ± 2.6		402	31.0 ± 2.4	0.031	382	15.3 ± 1.8	
Smoker	159	22.3 ± 3.8		103	24.1 ± 3.9	0.003	83	14.6 ± 18.9	
Snus user	22	22.8 ± 8.3		38	39.6 ± 8.7		44	17.1 ± 4.6	
PPD ≥ 4 mm (% sites)									
Non-user	352	9.6 ± 1.3	0.001	392	6.3 ± 1.0		382	7.6 ± 1.2	0.001
Smoker	157	15.9 ± 3.2		103	9.1 ± 2.7		83	16.7 ± 4.7	0.001
Snus user	22	8.4 ± 4.7		37	6.7 ± 3.6		44	5.8 ± 3.6	
BLI									
Non-user	352	43.5 ± 2.2	<i>0.001</i>	256	58.1 ± 0.6		372	60.8 ± 0.6	0.018
Smoker	156	45.8 ± 3.1	0.011	64	56.5 ± 1.9		79	58.7 ± 1.8	0.001
Snus user	22	59.7 ± 4.2		12	59.0 ± 3.0		44	63.8 ± 1.1	0.009
GR ≥ 1 mm (% sites)									
Non-user	358	11.9 ± 1.5		402	8.7 ± 1.0	0.036	382	8.1 ± 1.0	
Smoker	159	11.7 ± 2.3		103	8.5 ± 2.0		83	8.6 ± 2.3	
Snus user	22	5.6 ± 5.6		38	4.3 ± 2.6		44	7.9 ± 3.3	
Supragingival calculus (% sites)									
Non-user	352	2.7 ± 0.3		402	11.0 ± 1.2		382	11.4 ± 1.3	0.001
Smoker	157	3.1 ± 0.4		103	10.9 ± 2.4		83	22.1 ± 4.9	0.001
Snus user	22	2.5 ± 1.0		38	10.0 ± 3.3		44	9.3 ± 4.0	
Subgingival calculus (% sites)									
Non-user	352	21.2 ± 3.2		402	18.4 ± 2.7		382	14.2 ± 2.7	
Smoker	156	22.5 0/-5.0		103	23.5 ± 5.4		83	19.9 ± 7.2	
Snus user	22	22.7 ± 15.2		38	20.2 ± 10.4		44	12.5 ± 7.4	

Statistically significant differences between *p*-values for non-tobacco users and smokers are indicated in regular text style, for those between non-users and snus users in italics and for those between smokers and snus users in bold.

PLI, plaque index; GI, gingival index; PPD, probing pocket depth; BLI, bone level index; GR, gingival recession.

Table 3. Frequency (%) distribution of non-tobacco users, smokers and snus users according to the severity of periodontal disease experience (Groups 1, 2, 3, 4 and 5) in 1983, 1993 and 2003

Group	<i>n</i> (%)				
	1	2	3	4	5
1983					
Non-user	77 (22)	78 (22)	155 (44)	35 (10)	6 (2)
Smoker	40 (26)	32 (20)	53 (34)	25 (16)	6 (4)
Snus user	7 (32)	8 (36)	7 (32)	0 (0)	0 (0)
1993					
Non-user	89 (22)	151 (38)	110 (28)	38 (9)	11 (3)
Smoker	26 (26)	28 (27)	29 (28)	11 (11)	8 (8)
Snus user	6 (16)	23 (61)	7 (18)	2 (5)	0 (0)
2003					
Non-user	164 (43)	68 (18)	119 (31)	22 (6)	6 (2)
Smoker	28 (35)	10 (12)	22 (27)	10 (12)	11 (14)
Snus user	21 (48)	14 (32)	7 (16)	2 (4)	0 (0)

GI and PLI, with a variation of OR between 1.04 and 1.08 ($p < 0.001$), between GI and subgingival calculus, with a variation of OR between 1.01 and 1.02 ($p = 0.025$, $p = 0.003$ and

$p < 0.001$ in 1983, 1993 and 2003, respectively), and for GI and smoking, with a variation of OR between 0.29 and 0.43 ($p < 0.001$ –0.011). There was thus a lower risk of gingivitis for smokers

than for non-users. No association between gingivitis and snus use was found.

As regards the outcome variable PPD, in 1983, there was a statistically significant association between the frequency of PPD ≥ 4 mm and subgingival calculus (OR = 1.03; $p < 0.001$), smoking (OR = 2.44; $p < 0.001$) and snus use (OR = 3.98; $p = 0.020$). In 1993, there was an association between the frequency of PPD ≥ 4 mm and PLI (OR = 1.01; $p = 0.025$) and subgingival calculus (OR = 1.02; $p < 0.001$). In 2003, there was an association between the frequency of PPD ≥ 4 mm and PLI (OR = 1.06; $p < 0.001$), subgingival calculus (OR = 1.02; $p < 0.001$) and smoking (OR = 4.72; $p < 0.001$). There was no association between the frequency of PPD ≥ 4 mm and snus use.

As regards BLI, there was no significant association between BLI and smoking or snus use in any examination year.

Table 4. Results of the multiple logistic regression analysis of the association between the outcome variable periodontal disease experience (Groups 1, 2 and 3 versus Groups 4 and 5) and various explanatory variables in the different years of examination 1983, 1993 and 2003

Explanatory variables	OR	95% CI	p-value
1983 (<i>n</i> = 539)			
Non-users	1		
Smoking	3.94	2.06–7.55	0.001
1993 (<i>n</i> = 543)			
Subgingival calculus	1.02	1.01–1.03	0.002
Non-users	1		
Smoking	3.02	1.50–6.09	0.002
Snus use	0.75	0.14–4.11	NS
2003 (<i>n</i> = 509)			
PLI	1.03	1.01–1.04	0.001
Subgingival calculus	1.02	1.01–1.03	0.002
Non-users	1		
Smoking	6.50	2.73–15.48	0.001
Snus use	0.82	0.15–4.60	NS

Estimates are adjusted for age, gender, education, employment and marital status.
PLI, plaque index; NS, not significant.

However, for both non-users and smokers, there was a statistically significantly higher mean bone level in 2003 compared with 1983.

An analysis of the outcome variable periodontal disease experience in Groups 1, 2, 3 versus Groups 4 and 5 showed a statistically significant association between periodontal disease experience and smoking (OR = 3.94; $p < 0.001$) in 1983, between periodontal disease experience and subgingival calculus (OR = 1.02; $p = 0.002$) and smoking (OR = 3.02; $p = 0.002$) in 1993 and between periodontal disease experience and PLI (OR = 1.03; $p < 0.001$), subgingival calculus (OR = 1.02; $p = 0.002$) and smoking (OR = 6.50; $p < 0.001$) in 2003. In none of the years, 1993 and 2003, was there a significant association between periodontal disease experience and snus users (Table 4).

Discussion

The above results are based on three cross-sectional epidemiological studies of randomly selected samples of the population of Jönköping, Sweden, covering 20 years, 1983–2003. The results relating to the use of tobacco in the population are in agreement with the results of national Swedish studies (Statens folkhälsoinstitut 2009) and clearly show the trend towards reduced tobacco use. This trend is mirrored by the respondents in the study, where the total number of tobacco users has decreased from sample to sample over time. The use of snus, however, has increased in certain age groups, mainly among men, the traditional users, but also among

women. The increase in the use of snus among women has also been revealed in other Swedish studies (Statens folkhälsoinstitut 2009). The general decrease in smoking and increase in snus usage might be due to some smokers switching from cigarettes to snus; this in turn might result from the fact that it has not been proven conclusively that snus is as harmful to general health as smoking (Lee 2011).

A comparison of the oral health situation over time showed that non-users had better oral health, more teeth, better oral hygiene, less gingivitis, higher alveolar bone level and a lower incidence of severe periodontal disease in 2003 compared with 1983 and 1993. This is in agreement with the results of the oral health situation of the population within the city of Jönköping presented earlier (Hugoson et al. 2005a, b).

Numerous epidemiological studies have demonstrated that of all the risks identified, cigarette smoking may be the most strongly associated with periodontitis. This is in accordance with the results of this presentation, where the outcome variables, number of sites with PPD ≥ 4 mm and severity of periodontal disease experience, after adjustment for gender, age and sociodemographic variables, were statistically significantly associated with smoking in all three examination years. It is also in agreement with longitudinal studies conducted in 1973–1991, where it was demonstrated that moderate to heavy smoking, greater age and higher mean levels of plaque are potential risk indicators/factors for severe periodontal disease (Norderyd et al. 1999). This is

obviously a situation that still persisted in 2003.

The effect of smoking on gingivitis, masking the overt signs of inflammation, was also verified in this study in accordance with the results presented by Scott and Singer (2004).

As regards snus use, the current data show that, in 1983, there was an association between the frequency of PPD ≥ 4 mm and snus use (OR = 3.98; $p = 0.020$). However, this result could not be verified in 1993 and 2003. In no other analyses was there an association between outcome variables and snus use. Thus, snus use did not seem to be a risk factor for periodontal disease. These results are comparable to the results from studies presented by Bergström (2004b) and Montén et al. (2006), who found that snus had no major negative effect on the periodontal tissues in young individuals. Another study among young Swedish males, comparing snus users and non-tobacco users, showed no statistically significant difference in the number of teeth, plaque, gingivitis and the frequency of PPD (Rolandsson et al. 2005). Robertson et al. (1990) have presented similar results. However, in a comprehensive view of oral health, the effect of snus on the oral mucosa and exposed root surfaces should not be ignored.

When smokers were compared with snus users, statistically significant differences in the mean values for the number of teeth, frequency of PPD ≥ 4 mm, alveolar bone level and periodontal disease experience were found (Table 2). Further, after the multivariate comparison, smokers showed an increased risk of severe periodontal disease compared with non-smokers. In no analyses was there an association between any of the outcome variables and snus use.

In this study, covering age groups from 20 to 70 years of age, there were differences in the mean values between non-tobacco users and snus users regarding the number of teeth and alveolar bone height, and there were no snus users in periodontal disease Group 5 (in 1983 Groups 4 and 5). These differences were found to depend on differences in age between the groups but also that these individuals do not seem to have a higher risk of destructive periodontal disease.

The risk of periodontitis attributable to smoking (in 1983, OR = 3.94; in 1993, OR = 3.02 and in 2003,

OR = 6.50) found in this study is in accordance with other studies (Bergström & Preber 1994). The variables used in periodontal diagnoses and for the classification of periodontal disease have been discussed for many years (Baelum & Lopez 2003, Preshaw 2009). In order to produce reproducible data suitable for describing trends in periodontitis prevalence, it is necessary to establish consistent criteria for the clinical diagnoses (Machtei et al. 1992, Tonetti & Claffey 2005). It is notable that in these epidemiological investigations, the same criteria were used over the study period to evaluate the effects of cigarette smoking and snus usage on periodontitis.

One limitation in this study is that a cross-sectional study can provide only a momentary snapshot of individual oral health and habits. Although it is possible to track the general trends, it is not possible to track individuals and there is, therefore, a lack of information about how long different individuals have used tobacco and whether or not they have stopped using it or switched from one form to another.

Another limitation of the study is the small number of snus users, especially in 1983. However, similar results regarding the mean number of teeth, the frequency of PPD ≥ 4 mm, alveolar bone level and periodontal disease experience have been registered in the different examination years also when the number of snus users was more satisfactory.

Ceasing smoking may decrease the risk of different general diseases (Wanamethee et al. 1995). However, it will take different lengths of time for former smokers to approach non-smokers (Yanagisawa et al. 2009). In studies where former smokers are included, the degree of periodontal disease varies between non-users and current smokers (Bergström et al. 2000). In the present study, no information was available on former smokers in 1983 and 2003. In 1993, there was an attempt to obtain information about former smokers. However, the participants had difficulties in presenting clear data about when they quit smoking but they claimed that they were not smoking anymore and had not been doing so for a relatively long period. In this study, there was no statistically significant difference in the alveolar bone level between non-users and former smokers ($p < 0.001$). Former smokers were, therefore, included among non-users in 1993 as in the other

examination years. Contrary to the discussion of the degree of periodontitis among former smokers after they stopped smoking, the effect of quitting snus is more obvious. Oral mucosal changes are, in 3–6 months, reversible both clinically and histologically following the cessation of snus use while gingival recessions mostly will persist (Larsson et al. 1991).

Conclusion

In this study, cigarette smokers were found to have a statistically significantly higher risk of severe periodontal disease than non-tobacco users and users of snus. Using Swedish moist snuff (snus) did not seem to be a risk factor for periodontal disease. Thus, the hypothesis was verified.

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Clinical Relevance

Scientific rational for the study. There is strong evidence that cigarette smoking is a risk factor for periodontitis, but little is known about the effect of Swedish moist snuff (snus) on periodontitis. Statistical analyses of three epidemiologi-

cal cross-sectional studies covering a random sample of Swedish adult subjects show the effects on periodontal disease of smoking and using snus.

Principal findings: Cigarette smoking was shown to be a risk factor for

periodontal disease, whereas using snus was not.

Practical implications: In periodontitis prevention and treatment, patients should always be informed of the negative effect of smoking and of various strategies to quit smoking.