ALVEOLAR BONE LOSS AND TOOTH LOSS IN MALE CIGAR AND PIPE SMOKERS

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ABSTRACT

Background. While cigarette smoking is recognized as being detrimental to oral health, the effects of cigar and pipe smoking on tooth-loss risk, alveolar bone loss and periodontal disease are not known. The authors conducted this study to determine whether cigar and pipe smokers were at greater risk of experiencing tooth loss and alveolar bone loss than were nonsmokers.

Methods. The authors studied 690 dentate men who participate in the Veterans Affairs Dental Longitudinal Study. Subjects are not VA patients, and they receive medical and dental care in the private sector. A board-certified periodontist conducted clinical examinations triennially for 23 years. These examinations included the number of teeth remaining, number of decayed and filled surfaces per tooth, and indicator scores for plaque, calculus, pocket probing depth, gingival bleeding and tooth mobility. Alveolar bone loss was assessed at each examination on intraoral periapical radiographs using the Schei ruler method, which measures loss of bone height in 20 percent increments. Multivariate analyses of tooth-loss rates and alveolar bone loss controlled for demographic and oral hygiene measures.

Results. The relative risk, or RR, of tooth loss compared with that of nonsmokers was significantly elevated in cigar smokers (RR = 1.3, 95 percent confidence interval, or CI, = 1.2, 1.5), pipe smokers (RR = 1.6, 95 percent CI = 1.4, 1.9) and cigarette smokers (RR = 1.6, 95 percent CI = 1.5, 1.7). The percentages of mesial and distal sites with moderate-to-severe progression of alveolar bone loss (a change of 40 percent or more from baseline) were 8 ± 1 percent (mean ± standard error) in nonsmokers, 16 ± 3 percent in cigar smokers ($P < .05$), 13 ± 4 percent in pipe smokers ($P = .17$), and 16 ± 3 percent in cigarette smokers ($P < .001$). Pipe and cigar smokers did not differ significantly from nonsmokers with respect to the percentage of sites at baseline with moderate-to-severe scores for calculus, pocket probing depth, gingival bleeding or tooth mobility. Pipe smokers had fewer sites with moderate-to-severe plaque accumulation than did nonsmokers (7 ± 11 vs. 13 ± 17, $P < .05$).

Conclusions. The authors found that men who smoke cigars or pipes were at increased risk of experiencing tooth loss. Cigar smokers also were at increased risk of experiencing alveolar bone loss. These elevations in risk are similar in magnitude to those observed in cigarette smokers.

Clinical Implications. The increases in risk related to cigar and pipe smoking provide a strong rationale for targeting smoking prevention and smoking cessation programs to smokers of all tobacco products.

The per capita consumption of cigars in the United States has increased dramatically in the past few years. Since 1993, cigar sales have increased by 50 percent, reversing the previous 20-year trend of declining cigar consumption.[1] Cigar smoking once was associated primarily with older men, but now it is being taken up by young men and women. More than one-fourth of high-school students reported smoking at least one cigar during 1996.[2] Although the harmful effects of cigarette smoking—periodontal disease,[3-7] alveolar bone loss[4] and the risk of experiencing tooth loss[8-10]—have become more widely recognized, few studies have been done on the oral effects of cigar and pipe smoking.[5,10,11] Ismail and colleagues[11] reported on a large-scale epidemiologic study of periodontal disease that separately evaluated groups of cigar and pipe smokers. They found that the mean Russell periodontal index score for cigar smokers was higher than it was for nonsmokers but lower than it was for cigarette smokers; the difference, however, was not statistically signifi-

cant. They observed a similar pattern in pipe smokers.

Cigars and pipes are perceived by many smokers to have fewer health risks than cigarettes.[1] However, certain health risks—such as stroke[12,13] and cancers of the oral cavity, esophagus, liver and pulmonary tract[14]—to cigar or pipe smokers are equal to or greater than those to cigarette smokers.

If the severity of periodontal disease and risk of tooth loss among cigar and pipe smokers is similar to that among cigarette smokers, it would have important implications for dental treatment plans and would provide a stronger rationale for dentists to ensure that their smoking prevention and smoking cessation programs are targeted at users of all tobacco products. For example, cigarette smokers have a poorer prognosis for periodontal treatment[15-16] and a higher failure rate for dental implants than do nonsmokers.[17] If cigar and pipe smokers also have poorer outcomes, knowledge of patients' smoking habits may help dentists develop more appropriate treatment plans.

In a recent study,[10] we reported that the risk of experiencing tooth loss in a group of cigar and pipe smokers was higher than it was in nonsmokers. We did not, however, include alveolar bone loss data in our comparison.

We conducted this current study to evaluate alveolar bone loss and tooth loss separately by cigar- and pipe-smoking status and to describe differences in clinical periodontal disease indicators by type of tobacco product.

METHODS

The subjects in this study are participants in the Veterans Affairs Dental Longitudinal Study, or VADLS, a prospective observational study of oral health in a cohort of 1,231 male veterans in good medical health at baseline.[18] The VADLS was begun as an adjunct to the Normative Aging Study, or NAS, a closed-panel interdisciplinary study of aging in more than 2,000 community-dwelling men in the greater Boston metropolitan area. Ninety-seven percent of the men were white, and they ranged in age from 21 to 75 years when they enrolled in the NAS between 1963 and 1968. The men are not VA patients, and they receive their medical and dental care in the private sector. Written informed consent was obtained from each subject.

Comprehensive oral examinations were first performed in 1968 and were repeated triennially. Data from seven examination cycles, covering up to 23 years, are included in this study.

Clinical oral examinations were conducted by a board-certified periodontist. The number of teeth—including third molars—were counted at each examination; number and locations of decayed and/or filled surfaces per tooth were noted; and each tooth was scored for clinical periodontal indicators of plaque, calculus, pocket probing depth, gingival inflammation or bleeding, and tooth mobility.[19]

Alveolar bone loss was assessed at each dental examination cycle using a full-mouth series of intraoral periapical radiographs and the Schei ruler method.[20] Using the root apex and cementoenamel junction, or CEJ, as reference points, the reduction in alveolar bone height from the CEJ was measured separately on the mesial and distal aspects of each tooth present. Alveolar bone loss scores ranged from 0 to 5, with 0 indicating no loss and each subsequent number representing an increment of 20 percent loss of bone height.

Information on current and past types of tobacco products used, years of use, and number of pipefuls and cigars smoked daily were obtained at each examination. Dichotomous variables were formed to describe educational level (education beyond high school, no or yes), oral hygiene habit of toothbrushing frequency (at least twice a day, no or yes) and prophylaxis in the past two years (no or yes).

The 690 subjects in this study included all VADLS participants who were dentate at baseline and had at least two teeth remaining, returned for at least one oral examination over the follow-up period, had radiographic measurements of alveolar bone loss taken, and, if they smoked, used only one type of tobacco product during the follow-up period.

The sample for analysis included 50 men who smoked cigars exclusively during the follow-up period, 32 men who smoked pipes exclusively, 131 men who smoked cigarettes exclusively and 477 men who did not smoke during follow-up.

The group of nonsmokers included both those subjects who were never smokers and those who were former smokers—smoked any type of tobacco before the baseline examination but none during follow-up. The groups of cigar and pipe smokers also included some former smokers of another tobacco

DEFINITIONS OF CLINICAL SEVERITY USED IN SCORING PERIODONTAL INDICATORS.*

PERIODONTAL INDICATOR	CLINICAL SEVERITY	
	Moderate-to-Severe	None or Minimal
Plaque	Interproximal or continuing on buccal, lingual or all surfaces of two-thirds of tooth	None or interproximal surfaces only
Tooth mobility	Greater than 0.5 millimeters or vertical mobility	0.5 mm or less
Calculus	Noncontinuous, on one surface or circumferential band around tooth	None or discontinuous flakes
Pocket probing depth	More than 3 mm	3 mm or less
Gingival inflammation or bleeding	Bleeding on probing, severe alteration, marked inflammation or spontaneous bleeding	Normal, circumferential alteration or alteration of one surface only
Baseline levels of moderate-to-severe alveolar bone loss	Less than 80 percent of height remaining	80 to 100 percent of height remaining

* Adapted from Feldman and colleagues.[19]

product. A previous analysis of this population indicated that the risk of experiencing tooth loss in subjects whose only tobacco exposure occurred before the baseline examination was similar to the risk in those who never smoked.[10]

Statistical methods. For each subject, we calculated the percentage of teeth that had moderate or severe clinical periodontal indicator scores for plaque, tooth mobility, calculus, pocket probing depth and gingival inflammation or bleeding, as well as the percentage of mesial and distal sites with baseline levels of moderate-to-severe alveolar bone loss (Box). In our longitudinal analyses, we defined progression of alveolar bone loss as a change of 40 percent or more (that is, a change of two or more Schei units) from the baseline value.

Analyses of variance and the χ^2 statistic were used to evaluate differences among smoking status categories. We constructed general linear models (SAS, Version 6.12, SAS Institute) to identify significant covariates ($P < .05$) and adjust the mean values of percentage of teeth with alveolar bone loss progression and number of teeth lost in each smoking status category. We used multiple linear regression analysis to estimate the variance in the number of teeth lost during follow-up that was explained by baseline level of alveolar bone loss, alveolar bone loss progression and other significant covariates.

For the analysis of tooth loss, we calculated the follow-up period in tooth years. A tooth year is the length of time a tooth was followed, either until it was lost or until the last available examination cycle. If a tooth was lost, we estimated the observation period from baseline to the midpoint between the last cycle it was present and the first cycle it was missing. We computed tooth-loss incidence rates for each smoking status category as the total number of teeth lost between baseline and the last available examination divided by the sum of tooth years multiplied by 1,000. Relative risk, or RR, of tooth loss and test-based 95 percent confidence intervals, or CIs, were computed for each smoking group as the rate of tooth loss in that group divided by the rate of tooth loss in nonsmokers.

RESULTS

The baseline characteristics of the cohort, grouped by smoking status during the follow-up period, are shown in Table 1. We found no significant differences among the groups with respect to important covariates such as number of teeth remaining, percentage of teeth with moderate-to-severe scores of gingival bleeding and tooth mobility, number of decayed and/or filled surfaces per tooth, oral hygiene habits, percentage of subjects who had prophylaxis in the past year and percentage of subjects who were former cigarette smokers.

We found that cigarette

TABLE 1

BASELINE CHARACTERISTICS OF SUBJECTS IN THE VETERANS AFFAIRS DENTAL LONGITUDINAL STUDY, BY SMOKING STATUS DURING FOLLOW-UP.*

BASELINE CHARACTERISTICS	SMOKING STATUS			
	Nonsmoker	Cigar Smoker	Pipe Smoker	Cigarette Smoker
Number of subjects	477	50	32	131
Age†	49 ± 8‡	48 ± 8‡	47 ± 7	44 ± 7‡
Number of teeth remaining	25 ± 4	26 ± 4	25 ± 4	25 ± 5
Percentage of subjects with education beyond high school§	46	24	53	33
Percentage of teeth with moderate-to-severe scores**				
Calculus†	11 ± 17‡	15 ± 21	14 ± 21	20 ± 22‡
Probing depth†	5 ± 9‡	6 ± 10	5 ± 9	7 ± 11‡
Gingival bleeding	54 ± 24	55 ± 26	47 ± 27	55 ± 26
Tooth mobility	0.3 ± 2	0.1 ± 1	0.4 ± 2	0.3 ± 2
Plaque	13 ± 17‡	9 ± 12	7 ± 11‡	10 ± 17
Percentage of sites with moderate-to-severe alveolar bone loss at baseline†**	7 ± 15‡	13 ± 21	7 ± 12‡	13 ± 20‡
Number of decayed and/or filled surfaces per tooth	1.6 ± 1	1.5 ± 1	1.4 ± 1	1.4 ± 1
Percentage of subjects who brush at least twice a day	45	38	28	42
Percentage of subjects who had no prophylaxis in the past two years	14	12	28	17
Percentage of subjects who are former cigarette smokers	52	66	52	NA††

* Mean ± standard deviation or percentage is shown.
† Significant differences among smoking status categories by analysis of variance F statistic, $P < .05$.
‡ Means are different from one another, $P < .05$.
§ Significant differences among smoking categories by χ^2 statistic, $P < .05$.
** For definitions of severity, see the box.
†† NA: Not applicable.

smokers were younger than nonsmokers and cigar smokers. Cigarette smokers also had significantly more teeth at baseline with moderate-to-severe calculus and pocket probing depth scores and more mesial and distal sites with moderate-to-severe alveolar bone loss than did nonsmokers. Pipe smokers had fewer teeth at baseline with moderate-to-severe plaque scores than did nonsmokers. Cigar and cigarette smokers were less likely to have education beyond high school than were pipe smokers and nonsmokers.

Mean values of the percentage ± standard error, or SE, of mesial and distal sites with moderate-to-severe alveolar bone loss progression are shown in the figure by smoking status during follow-up. Cigar and cigarette smokers had significantly more ($P < .05$ and $P < .001$, respectively) mesial and distal sites with alveolar bone loss progression (16 ± 3 percent and 16 ± 2 percent, respectively) than did nonsmokers (8 ± 1 percent). The mean percentage ± SE of mesial and distal sites with alveolar bone loss progression among pipe smokers (13 ± 4 percent) was intermediate to that of nonsmokers and cigar smokers but was not significantly different from that of nonsmokers ($P = .17$). Adjustment for the number of decayed and/or filled surfaces per tooth, percentage of teeth with moderate-to-severe pocket probing depth scores and percentage of mesial and distal sites with baseline level of moderate-to-severe alveolar bone loss did not substantially alter the means or *P*-values. When mesial and distal sites were analyzed separately, the results were consistent.

Rates of tooth loss by smoking status are shown in Table 2. The RR of tooth loss in each of the cohorts of smokers was significantly higher than was the RR in nonsmokers when controlled for age, education, number of teeth remaining at baseline, percentage of mesial and distal sites with baseline levels of moderate-to-severe alveolar bone loss and percentage of teeth with baseline moderate-to-severe pocket probing depth scores. The 95 percent CIs of the cigar, pipe and cigarette smokers overlapped one another, which suggests the RRs are comparable among all groups of smokers.

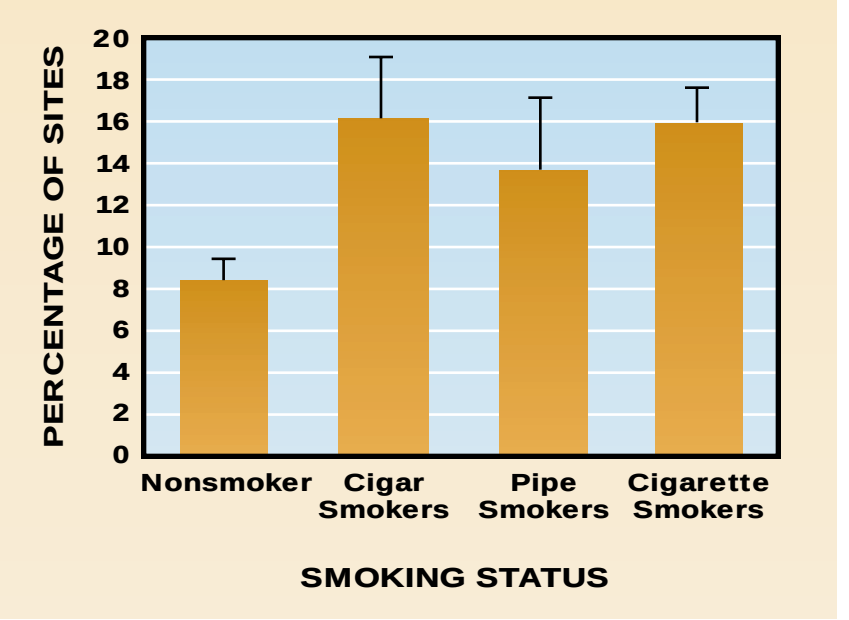

Figure. Mean percentage of mesial and distal sites (± 1 standard error) with alveolar bone loss progression (40 percent or more change in height, or two or more Schei units) from baseline, by type of tobacco product used exclusively during follow-up.

In the longitudinal multivariate analyses, we found that the percentage of mesial and distal sites with a baseline level of moderate-to-severe alveolar bone loss and the percentage of mesial and distal sites with alveolar bone loss progression were significant positive predictors of per-person tooth loss (Table 3). That is, the greater the percentage of teeth with alveolar bone loss or alveolar bone loss progression, the more teeth that were lost during follow-up. Age, number of teeth remaining at baseline, percentage of teeth with moderate-to-severe pocket probing depth scores and being a smoker also were associated positively with tooth loss. We found that education beyond high school was inversely associated with the number of teeth lost.

DISCUSSION

It has been well-established that cigarette smoking is associated with alveolar bone loss and tooth loss even when researchers control for oral hygiene and other sociodemographic and behavioral factors.[3-10] The results of this study suggest that alveolar bone loss and tooth loss among cigar and pipe smokers occur at rates similar to those among cigarette smokers.

Our findings are the first to clearly demonstrate—using multivariate analyses and a longitudinal study design—that men who smoke cigars or pipes also are at greater risk of experiencing tooth loss than are nonsmokers. Moreover, the tooth-loss rates among cigar or pipe smokers were very similar to the tooth-loss rate among cigarette smokers.

The elevations in RR of tooth loss among cigar smokers, pipe smokers and cigarette smokers are remarkably consistent with our previous analysis of smoking and tooth loss,[10] even though

TABLE 2

RATE AND RELATIVE RISK OF TOOTH LOSS, BY SMOKING STATUS .*

SMOKING STATUS	N	RATE OF TOOTH LOSS PER 1,000 TOOTH YEARS†	RR OF TOOTH LOSS (95 PERCENT CI)
Nonsmoker	477	9.2	1.0
Cigar Smoker	50	12.2	1.3 (1.2-1.5)
Pipe Smoker	32	15.0	1.6 (1.4-1.9)
Cigarette Smoker	131	14.7	1.6 (1.5-1.7)

* Adjusted Relative Risk, or RR, with 95 percent confidence intervals, or CI. RR was computed with nonsmokers as the reference group.
† Rates were adjusted for age, education, number of teeth at baseline, percentage of sites with moderate-to-severe levels of alveolar bone loss at baseline and percentage of teeth with baseline moderate-to-severe pocket probing depth scores. Further adjustment for oral hygiene, number of decayed and/or filled surfaces per tooth, percentage of former cigarette smokers, and percentage of teeth with moderate-to-severe calculus, plaque, gingival inflammation or bleeding, and tooth mobility did not change the results.

several important methodological differences exist. In our previous study, cigar and pipe smokers were combined into one group, and the group of cigarette smokers included a percentage of smokers who concurrently smoked other tobacco products. In our present study, we took care to include only men who smoked cigars, pipes or cigarettes exclusively during the follow-up period.

In our previous study, we examined tooth-loss rate after those subjects successfully quit.[10] In our present study, we did not have enough statistical power in the discrete cigar and pipe smoker groups to separately compute tooth-loss rates by cessation status. As a result, the tooth-loss rates we show here are averages of tooth loss during smoking and after cessation and, thus, are likely to be conservative estimates of the true risks of tooth loss in cigar and pipe smokers. As we showed in our previous study,[10] even though men who quit smoking cigarettes have a reduced rate of tooth loss after they quit smoking, they had a modest elevation in tooth-risk loss—which persisted for many years—compared with nonsmokers. Our exclusion of former cigarette smokers to remove this carry-over effect may have lowered the tooth-loss rates somewhat, but we expected that the relative differences in tooth-loss rates and RR would remain the same because the percentages of former cigarette smokers were similar in each group of tobacco users.

Among cigar smokers, the percentage of mesial and distal sites at baseline with moderate-to-severe levels of alveolar bone loss was intermediate to those of nonsmokers and cigarette smokers, while the corresponding percentage of sites in pipe smokers was similar to that of nonsmokers. In an earlier cross-sectional study of this cohort, Feldman and colleagues[5] reported that the average whole-mouth score for alveolar bone loss at baseline did not differ between nonsmokers and a group of cigar and pipe smokers. This discrepancy between our findings and theirs may have resulted from Feldman and colleagues' combining of cigar and pipe smokers in one group; we found that cigar and pipe smokers were heterogeneous with respect to baseline levels of alveolar bone loss and alveolar bone loss progression. Tooth-loss rates in all smokers—cigar, pipe and cigarette smokers—were 30 to 60 percent higher than the tooth-loss rate in nonsmokers.

Evidence for differences in oral hygiene measures and clinical periodontal indicators—such as pocket probing depth and tooth mobility—by smoking status was less strong. Cigar smokers had a somewhat greater percentage of teeth at baseline with deep pocket probing depths than did nonsmokers, but the difference did not reach statistical significance. Tooth mobility of 0.5 millimeters or greater was infrequent in all groups at baseline. In a study by Ismail and colleagues,[11] both cigar and pipe smokers had mean Russell periodontal indexes that were higher than nonsmokers, but lower than cigarette smokers. The differences, however, were not statistically significant. Although both the Ismail and colleagues study and our current study suggest cigar smokers tend to have poorer periodontal status than nonsmokers, the number of cigar smokers in each study still may have been too small to reveal significant

TABLE 3

PREDICTORS OF TOOTH LOSS OVER 23 YEARS OF FOLLOW-UP.*†

PREDICTORS	COEFFICIENT (B ± SE‡)	*P*-VALUE	PARTIAL R^2
Intercept	-4.1 ± 1.6	< .01	Not Applicable
Percentage of sites with moderate-to-severe alveolar bone loss at baseline	0.05 ± 0.01	< .001	0.12
Percentage of sites with alveolar bone loss progression	0.07 ± 0.01	< .001	0.11
Smoking status during follow-up§	0.47 ± 0.14	< .001	0.02
Education**	-0.89 ± 0.32	< .01	0.01
Age	0.05 ± 0.02	< .05	0.01
Number of teeth remaining at baseline	0.19 ± 0.04	< .001	0.04
Percentage of teeth with moderate-to-severe pocket probing depth scores at baseline	0.04 ± 0.02	< .05	0.01

* Results of multiple linear regression model in which the number of teeth lost during follow-up was the dependent variable.
† The partial coefficient of determination for multivariate analysis, or R^2, shown for each variable was adjusted for all other variables in the model.
‡ B: Regression coefficient; SE: Standard error.
§ Nonsmoker, cigar smoker, pipe smoker or cigarette smoker.
** Dichotomized to education beyond high school (no or yes).

differences. It remains to be determined if clinical periodontal indicators differ by type of tobacco product used and how much they contribute to tooth loss risk.

Our results are consistent with the hypothesis that progressive alveolar bone loss is an important causal mediator of tooth loss. The baseline level of moderate-to-severe alveolar bone loss and the progression of alveolar bone loss over the follow-up period were important significant predictors of the number of teeth lost and explained a relatively large part of the variance in tooth-loss incidence in multivariate regression models. In addition to smoking, we found that age, education, number of teeth remaining at baseline and percentage of teeth with moderate-to-severe pocket probing depth scores were significant predictors of tooth loss, but they explained a smaller part of the variance in tooth loss in the multivariate analyses.

A limitation of our study was the relatively small numbers of cigar and pipe smokers available for analysis after we excluded smokers of more than one type of tobacco product from the study. Thus, we were not able to examine important questions such as dose-response patterns of alveolar bone loss and tooth loss, or the effect of occasional cigar or pipe use.

Another limitation was our reliance on the subjects' self-reports of smoking habits. The nicotine content of cigars varies widely and a single cigar may have two to six times the nicotine content of a cigarette or pipeful of tobacco.[1,7,21] Correlating a biochemical index of tobacco exposure level, such as cotinine,[22] with alveolar bone loss and tooth loss would greatly strengthen and add validity to the findings. In addition, the Schei ruler method we used to determine alveolar bone loss is not sensitive to increments smaller than 20 percent. We were able to detect differences by smoking status in large amounts of alveolar bone loss (40 percent or more from baseline), but percentages of mesial and distal sites with lesser amounts of bone loss also may differ in cigar and pipe smokers. More sensitive and precise methods of measuring alveolar bone[23,24] may clarify the relationship between smoking and alveolar bone loss.

CONCLUSIONS

This study indicates that cigar smokers experience tooth loss

and alveolar bone loss at rates equivalent to those of cigarette smokers. Pipe smokers also have a risk of experiencing tooth loss that is similar to that of cigarette smokers. Further studies using improved methods of measuring alveolar bone loss and a refinement of smoking exposure status are needed to confirm our findings.

If confirmed, our findings may have several important implications for health care professionals. For example, proof that cigar and pipe smokers are at an increased risk of experiencing tooth loss and alveolar bone loss strengthens the rationale for encouraging cigar and pipe smokers, not just cigarette smokers, to participate in smoking cessation programs.[25]

The greatest percentage increase in cigar use since 1990 has been documented in teenagers and young adult white men.[1] However, minority populations in the United States are using tobacco products at an increasing rate, and both the number of minorities and the number of minorities who smoke are expected to increase by nearly 50 percent over the next 50 years.[26] If the current trend in cigar consumption continues, tooth loss may become increasingly prevalent in these segments of the population. ■

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