

Smoking and Smokeless Tobacco: Increased Risk for Oral Pain

Joseph L. Riley III,* Scott L. Tomar,* and Gregg H. Gilbert†

Abstract: Tobacco has been linked with several pain conditions that include musculoskeletal pain, rheumatoid arthritis, and fibromyalgia. This study documented associations between smoking and smokeless tobacco use and measures of orofacial pain and oral pain impacts (activity reduction and trouble with sleep) assessed during a 48-month time period. These data were collected as part of the Florida Dental Care Study, a longitudinal study of oral health among 873 adults aged 45 years and older at baseline. Twenty-five percent of the study participants were current users of some form of tobacco, and 34% were former users. Separate models were tested for smoking and smokeless tobacco. Current tobacco users were at increased risk of experiencing a range of painful oral symptoms. We also found that behavioral impacts associated with oral pain are sensitive to differences in tobacco use status. Our data also support the supposition that once tobacco cessation occurs, the risk for pain associated with oral disease decreases significantly. No differences were found between former users and those never having used tobacco across any of the pain measures. Strengths of the current study include the longitudinal methodology, assessment of different pain symptoms with potentially differing etiology, and that several markers of tobacco use were used (prevalence, consumption, and duration).

Perspective: *This study considers the harmful effects of tobacco use on oral health. Smokers were at significantly increased risk for oral pain and related limitation of daily activities. The data also suggest that the risk for oral pain associated with tobacco use decreases significantly if tobacco cessation occurs.*

© 2004 by the American Pain Society

Key words: *Tobacco, smoking, orofacial pain, oral health, pain impact.*

In 2000, 31.3% of men and 21.3% of women in the United States used some form of tobacco.¹⁶ Smoking adversely affects nearly all tissues and systems in the body and is an established risk factor for many diseases including several cancers and cardiovascular disorders.⁴ Tobacco use is also linked with several pain conditions that include musculoskeletal pain,^{2,12,13,24,25,28,35,44} rheumatoid arthritis,^{20,23,33,38} and fibromyalgia.⁴⁵

Smoking³⁹ and the use of smokeless tobacco^{5,40} have been identified as risk factors for clinical signs of oral disease in several large field examination studies. Although research on oral health–related quality of life suggests that subjective measures of oral health might be more useful than clinical indexes with regard to how oral health affects the lives of individuals,^{3,14} few studies have documented associations between tobacco use and painful oral symptoms or pain-related behavioral im-

pacts. We were able to find 3 studies that suggested these relationships. Among dental patients, associations between dentin sensitivity and smoking have been reported.^{1,30} In the only community-based study, Unell et al⁴¹ found that tobacco use was associated with an increased probability of toothache pain. However, that study was limited by not disaggregating former smokers from persons who have never smoked. Another epidemiologic study that assessed pain of the face without designating the location (ie, oral cavity) found no association between smoking and pain.²

The objective of this study was to explore the association between smoking and smokeless tobacco use at the onset of the study with a range of measures of oral pain (tooth pain, painful gums, and temperature sensitivity) and oral pain impacts (activity reduction and trouble with sleep) assessed during a 48-month time period.

Methods

Sampling Methods

Data for this study were drawn from the Florida Dental Care Study (FDCCS), a longitudinal observational cohort study of oral health and dental care use, the field phase of which began in 1993 and ended in 2000. More detail on the study is provided at the Internet site listed in the Acknowledgements. A telephone screening methodology was used to identify persons who met eligibility cri-

Received March 23, 2004; Revised March 23, 2004; Accepted March 24, 2004.

From the *Division of Public Health Services and Research, College of Dentistry, University of Florida, Gainesville, Florida, and †Department of Diagnostic Sciences, School of Dentistry, University of Alabama at Birmingham, Birmingham, Alabama.

Supported by NIH DE-12587, DE-11020 and DE-14164. Additional support was provided by funds from the University of Florida.

Address reprint requests to Joseph L. Riley III, PhD, PO Box 100404 HSC, University of Florida, Gainesville, FL 32610-0404. E-mail: JRILEY@DENTAL.UFL.EDU

1526-5900/\$30.00

© 2004 by the American Pain Society

doi:10.1016/j.jpain.2004.03.003

Table 1. Prevalence of Tobacco Use by Sex, Race, and Age

CHARACTERISTIC	N	CURRENT	FORMER	NEVER
Smoking (N)		122	229	362
Men	225	22% (50)	48% (109)	30% (66)
Women	488	15% (72)	24% (120)	61% (296)
Black	298	17% (49)	27% (82)	56% (166)
White	412	18% (72)	35% (145)	47% (195)
Age, 45-64 y	358	27% (95)	32% (113)	42% (150)
Age, 65+ y	355	8% (27)	32% (115)	60% (213)
Smokeless tobacco use (N)		33	69	604
Men	223	6% (15)	19% (42)	75% (167)
Women	483	4% (18)	5% (27)	91% (437)
Black	293	10% (28)	13% (38)	77% (227)
White	410	1% (5)	7% (31)	92% (374)
Age, 45-64 y	356	4% (12)	10% (36)	86% (308)
Age, 65+ y	350	6% (21)	9% (33)	85% (296)

teria, from whom a stratified random sample was selected to participate at baseline. The sampling methodology and selection are provided in an earlier publication.¹⁵ The 873 subjects who participated at baseline were a representative sample of the population defined as those who (1) resided in 1 of the 4 counties of interest, (2) were English-speaking, (3) were capable of engaging in a cogent telephone conversation, (4) resided in a household, in contrast to a congregate facility, (5) reported race as non-Hispanic black or non-Hispanic white, and (6) had at least 1 remaining natural tooth. Four counties in north Florida were selected because they provided an urban/rural contrast, have large percentages of blacks, older adults, and poor individuals, were geographically proximate, and were near the administrative base for the project. Less than 2% of the persons in those counties considered themselves to be Hispanic.

By 48 months, 714 persons (unweighted n) remained in the study. Demographic information for the 714 participants is presented in Table 1. Of the 159 persons who were not available for the 48-month interview, 60 were deceased, 40 refused, 15 were medically unable to participate, and 44 were unreachable. Persons who participated at 48 months were more likely than dropouts to have been regular dental care attenders, above the 100% poverty threshold, in better self-rated general health, white, younger, and free of active dental caries at baseline. No differences in participation were observed with respect to sex, area of residence, or dental insurance status. The possible effect of this attrition on pain prevalence is suggested by differences in baseline prevalence of toothache pain. At baseline (n = 873), 12.1% of persons reported current toothache pain. If the baseline had only included persons who ultimately participated at 48 months, then that figure would have been 12.4%. This difference was not statistically significant. One person did not respond to the questions about smoking, and 8 did not respond to questions about chewing tobacco or snuff use. An additional 32 only responded to the ques-

tion about painful gums, because by the 48-month clinical examination they had no remaining teeth.

Interview Methods

Trained interviewers administered the baseline interview, which lasted approximately 30 minutes. Interviewers collected a wide range of information including demographic data. Test-retest coefficients ranged from 1.00 to 0.77 in a subset of 42 subjects over an average interval of 4 days. Immediately after the baseline interview a clinical examination was performed. The baseline interview and clinical examination were followed by a telephone interview at 6-month intervals. At 24 and 48 months after baseline, the interview was performed in person instead of by telephone, and this was followed immediately by a clinical examination that was identical to the baseline examination.

This project was approved by the University of Florida Institutional Review Board. The informed consent of all human subjects who participated in this investigation was obtained after the nature of the procedures had been explained fully.

Measures

Tobacco Status

At baseline, study participants were asked whether they had smoked at least 100 cigarettes or cigars in their lifetime and whether they still smoked at the time of the interview. Those who reported smoking at least 100 cigarettes or cigars and who smoked at the time of the baseline interview were classified as current smokers, former smokers had smoked at least 100 cigarettes or cigars but were no longer smoking, and never smokers were those who had not smoked 100 cigarettes or cigars in their lifetime. Current smokers were asked the number of years that they had been smoking and the number of cigarettes or cigars smoked per day. Participants also were asked whether they ever used chewing tobacco or snuff; those who reported ever using those products

Table 2. Duration of Tobacco Use Among Current and Former Users by Type of Tobacco

	CURRENT	FORMER
Duration of smoking		
5 y or less	2%	17%
6-10 y	2%	15%
11-19 y	19%	28%
20-29 y	27%	17%
30+ y	50%	23%
Duration of smokeless tobacco use*		
5 y or less	18%	
6-10 y	14%	
11-19 y	28%	
20-29 y	17%	
30+ y	23%	

*The smokeless tobacco duration variable did not distinguish between current or former users.

were asked whether they currently used it. Those who reported ever using chewing tobacco or snuff were asked the duration of use; current users also were asked the frequency of use.

Oral Pain and Pain Impact

At each follow-up interview, respondents were asked about dental problems they had experienced since the last interview. They were asked about toothache or painful tooth, sensitivity to hot or cold fluids or to sweets, infected or sore gums, oral pain or discomfort restricting normal activity, and trouble sleeping because of oral pain or discomfort.

Control Variables

History of dental care was assessed by a question that asked about the number of visits to a dentist since the last interview and a question that allowed respondents to be classified as problem-oriented or regular attenders. Present financial status was assessed with a question that asked about the ease with which financial obligations are met. Oral hygiene was assessed with 2 items asking about daily tooth brushing and the frequency of flossing.

Statistical Methods

We tested for an association between tobacco use and painful oral symptoms and pain impacts by using 2 methods to operationally define the oral pain-related outcomes, the number of 6-month interviews during the first 48 months of the FDCS at which the respondent reported experiencing each of the target pain variables (metric variable) and whether the oral pain outcome occurred once or more during the study (dichotomous variable). For the dependent variables that used a metric scale, a general linear model was used. For the dichotomous dependent variables, a series of logistic regression models were used. The independent variables, tobacco use status, were categorized as current, former, or never having used cigarettes/cigars or smokeless tobacco. Vari-

ables known to be associated with oral health were entered as control variables in all analyses (history of dental care, financial status, dental insurance, education, oral hygiene, and age). Because oral pain and pain impact are known to vary as a function of sex and race, sex, race, and their interaction terms with smoking status were also entered in the statistical models. Bivariate relationships were tested with the Pearson product moment correlation or Spearman rho as appropriate.

Results

Tobacco Use and Pain Status

One hundred twenty-two (17%) of the FDCS respondents indicated they were current smokers, 229 (32%) were former smokers, and 362 (51%) had never been smokers. Thirty-three (5%) reported they were current users of chewing tobacco or snuff, 69 (10%) were former users, and 604 (86%) had never been users. The duration of smoking and smokeless tobacco use is presented in Table 2. Current smokers had been smoking for an average of 32.6 years (standard deviation [SD], 12.7; range, 3-60) and smoked an average of 0.97 packs per day (SD, 0.88; range, 0.1-5.8). Former smokers had smoked for an average of 21.1 years (SD, 15.2; range, 0.5-85) and smoked an average of 0.85 packs per day (SD, 0.63; range, 0.1-4.0). Those who ever used smokeless tobacco reported using for an average of 10.4 years (SD, 13.6; range, 1-65). Of the current smokeless tobacco users, 18 (56%) reported using smokeless tobacco more than once a day, 11 (34%) every day, 3 (6%) several times each week, and 1 (3%) less than once a week.

Fifty-two percent of the FDCS respondents reported tooth pain during 1 or more of the 6-month interviews (mean, 1.2; SD, 1.3) between baseline and 48 months. Sixty-four percent reported temperature sensitivity of the teeth (mean, 2.0; SD, 1.6), 50% reported painful gums (mean, 1.2; SD, 1.4), 25% reported oral pain reduced activity reduction (mean, 0.5; SD, 0.7), and 32% reported trouble sleeping because of oral pain (mean, 0.6; SD, 0.8).

Duration and Consumption of Tobacco Use and Oral Pain

Among current smokers, significant negative correlations were found between years smoked and tooth pain ($r = -.21$; $P = .03$), temperature sensitivity ($r = -.28$; $P < .01$), and activity reduction because of oral pain ($r = -.20$; $P = .04$). Positive correlations were found among current smokers between the number of packs of cigarettes smoked per day and tooth pain ($r = .27$; $P < .01$), temperature sensitivity ($r = .26$; $P < .01$), activity reduction ($r = .24$; $P < .01$), and trouble with sleep ($r = .24$; $P = .01$). Among former smokers, no significant associations were found between any of the pain outcomes and duration or packs smoked. Among smokeless tobacco users, positive correlations were found between duration of use and temperature sensitivity ($r = .34$; $P = .02$), painful gums ($r = .32$; $P = .02$), and trouble with sleep ($r = .37$; $P < .01$). Associations were also found between the fre-

Table 3. Adjusted Means* and 95% Confidence Intervals for Oral Pain and Pain Impact Variables

PAIN VARIABLE	CURRENT, MEAN (95% CI)	FORMER, MEAN (95% CI)	NEVER, MEAN (95% CI)
Smoking			
Tooth pain	1.58 (1.39-1.77)	1.06 (0.87-1.25)	1.07 (0.87-1.27)
Painful gums	1.42 (1.13-1.71)	1.10 (0.90-1.31)	1.11 (0.91-1.32)
Temperature sensitivity	2.36 (1.87-2.85)	1.96 (1.57-2.36)	1.92 (1.52-2.33)
Activity reduction	0.85 (0.70-0.99)	0.28 (0.18-0.38)	0.36 (0.26-0.46)
Trouble sleeping	0.86 (0.69-1.03)	0.48 (0.30-0.60)	0.44 (0.36-0.52)
Smokeless tobacco use			
Tooth pain	1.34 (0.69-1.99)	1.16 (0.75-1.57)	1.15 (1.00-1.30)
Painful gums	2.35 (1.69-2.99)	1.27 (0.87-1.67)	1.04 (0.91-1.13)
Temperature sensitivity	2.73 (1.94-3.52)	2.26 (1.71-2.80)	1.89 (1.69-2.09)
Activity reduction	0.70 (0.30-1.10)	0.38 (0.23-0.53)	0.50 (0.40-0.60)
Trouble sleeping	0.52 (0.15-0.89)	0.50 (0.27-0.73)	0.48 (0.40-0.56)

*Mean number of intervals in which each pain variable was reported, adjusted for race, sex, age, oral hygiene, dental care, and education.

quency of current smokeless use and temperature sensitivity ($r = .37$; $P = .05$), painful gums ($r = .37$; $P = .05$), and trouble with sleep ($r = .34$; $P = .06$). The above values are partial correlations, adjusting for age at baseline.

Tobacco Use and Pain

Adjusted means for the number of interviews reporting each of the oral pain and pain impact variables by tobacco use status are presented in Table 3. Main effects for smoking status were found for tooth pain ($F = 6.552$; $P < .01$), painful gums ($F = 3.452$; $P = .03$), activity reduction ($F = 11.962$; $P < .01$), and trouble with sleep ($F = 5.211$; $P < .01$). A significant sex by smoking status interaction for tooth pain was also found ($F = 4.524$; $P = .01$). Marginal cell means were as follows: men who are current smokers, 1.8; former, 0.9; never, 1.0; women, current, 1.2; former, 1.2; never, 1.2. Test of simple effects indicated that the cell mean for male smokers was significantly larger than the other 5 smoking status \times sex cells ($P < .05$). For smokeless tobacco use, main effects for

smoking status were found for painful gums ($F = 5.752$; $P < .01$).

Odds ratio estimates for reporting pain or pain impact at least once by tobacco status are presented in Table 4. Current smoking or current smokeless tobacco use was associated with the odds of reporting tooth pain, activity reduction from oral pain, and trouble sleeping because of oral pain compared with never users. Current smoking or smokeless tobacco use was associated with the odds of reporting both activity reduction and trouble sleeping because of oral pain compared with former users.

Discussion

The purpose of this study was to examine the relationship between the use of tobacco and oral pain. We found that current smoking status increased the risk of experiencing a range of painful oral symptoms and pain impacts. In addition, current users of chewing tobacco or snuff reported more pain from the soft tissue of the mouth than former smokeless tobacco users or those

Table 4. Odds Ratio Estimate for Reporting Pain or Pain Impact at Least Once by Tobacco Use Status

PAIN VARIABLE	CURRENT VS NEVER USER	CURRENT VS FORMER USER	FORMER VS NEVER USER
Smoking			
Tooth pain	1.5 (1.2-2.6)*	2.1 (1.3-3.7)†	0.8 (0.6-1.3)
Painful gums	1.3 (0.8-2.2)	1.2 (0.8-2.1)	0.9 (0.7-1.3)
Temperature sensitivity	1.5 (0.9-2.4)	1.1 (0.8-1.3)	0.8 (0.6-1.3)
Activity reduction	2.1 (1.3-3.5)†	2.1 (1.3-3.2)†	0.9 (0.2-1.6)
Trouble sleeping	2.0 (1.2-3.5)*	1.4 (0.8-3.0)	1.7 (0.9-3.0)
Smokeless tobacco			
Tooth pain	1.0 (0.4-2.3)	1.2 (0.4-2.7)	1.2 (0.7-2.1)
Painful gums	1.7 (1.2-2.1)†	1.8 (0.7-3.0)	0.8 (0.4-1.5)
Temperature sensitivity	1.9 (0.9-4.0)	1.2 (0.7-1.9)	0.8 (0.5-1.4)
Activity reduction	1.4 (0.4-3.0)	1.0 (0.3-3.2)	1.3 (0.5-3.2)
Trouble sleeping	0.8 (0.3-2.5)	0.4 (0.1-1.7)	1.1 (0.4-2.5)

NOTE. Odds ratios and 95% confidence intervals are for current users compared to those who have never used tobacco in column 2, current users compared to former users in column 3, and former compared to never users in column 4 adjusted for race, sex, age, oral hygiene, dental care, and education.

* $P < .05$.

† $P < .01$.

who never used those products. Our data also support the supposition that quitting tobacco use significantly decreases the risk for pain associated with oral disease. To our knowledge, this study was the first investigation to document the impact of tobacco use on indicators of oral pain and pain impact.

The baseline prevalence of smoking in the FDCS cohort was very similar to contemporaneous national estimates. For example, 27% of participants aged 45 to 65 years were current smokers in our study, compared with 27.3% in that age group nationally in 1992.¹⁷ Similarly, the prevalence of current smokeless tobacco use among men in the FDCS (6.7%) was comparable to national estimates (5.6% in 1991) for men aged 45 years and older,¹⁶ but it was higher among women in the FDCS (4% vs 1%).

Tobacco Use and Pain

After adjusting for history of dental visits, overall approach to dental care, financial status, dental insurance, education, oral hygiene, and age, current smokers reported experiencing more tooth pain and painful gums than former smokers or respondents who have never smoked tobacco products. Our findings corroborated those reported by Unell et al⁴¹ from data collected by using a postal survey of Swedish adults. They found that smoking status, recorded as currently smoking compared to not currently smoking, increased the odds of experiencing tooth pain during the previous 12 months by a factor of 1.3. With a criterion of reporting tooth pain at 1 or more of the 6-month interviews, we found that current smokers at baseline were at increased risk by a factor of 1.7 over those who had never smoked. Our finding of a greater risk from smoking could be attributed to our not including former smokers in the non-smoker category.

Our findings did not support those reported by Al-Wahadni and Linden¹ or Rees and Addy³⁰ regarding associations between smoking and sensitivity of the teeth to temperature. One possible explanation could be the range of confounding variables that were controlled in our analyses. Whereas Al-Wahadni and Linden matched on age and sex and adjusted for tooth brushing in their analysis and tested for differences on a rating of pain, Rees and Addy tested for differences in the number of sensitive teeth but did not control for any person-level differences. Andersson et al² also failed to find differences by using a pain drawing to assess pain in the head or face.

The effect of smoking on tooth pain only occurred among men. That only men who smoke are at increased risk also has been reported for back pain²⁵ and rheumatoid arthritis.²³ These findings seem to be in contrast to a growing literature indicating that women are more likely to report a variety of temporary and persistent pains and to report pain of greater severity and a longer duration in comparison with men.⁴² In a previous report from FDCS data, there were no sex differences in the 6-month point prevalence of tooth pain at the 42-month interview.³²

Consistent with findings that the use of smokeless tobacco is associated with localized periodontal destruction^{6,10} and oral mucosal lesions,^{10,18,19,26,37,39} our data indicated that current users reported more pain than persons who formerly or never used those products. Current smokeless tobacco use predicted both of the gum-related pain outcomes, the number of 6-month follow-ups at which painful gums were reported and reporting gum pain at 1 or more of the interviews. The size of the effect for the difference between current users and those who never used smokeless tobacco on the number of interviews in which gum pain was reported was 0.5 SD units,⁹ the largest effect we found.

Pain-Related Functional Reduction and Tobacco

Studies of clinical patients with pain frequently document the behavioral impact of pain as decrements in daily activities.⁸ Differences have also been reported for the behavioral impact of oral pain across sex, age, and race.³² However, very few studies have tested for reductions in physical functioning or sleep disturbance resulting from pain as a function of tobacco use status. We found that pain impact as measured by activity reduction and trouble sleeping was increased for current smokers with no differences between former smokers and those who never smoked. The effect sizes for current smoking compared with never smoking were greater than 0.4 SD, a difference that approaches a moderate effect size.⁹

Several studies have also documented greater pain-related functional reduction among smokers. Reporting data from a clinical sample of patients with fibromyalgia, Yunus et al⁴⁶ found significant differences for functional status when comparing current smokers and nonsmokers, and the association between sleep difficulty and smoking approached significance. Palmer et al²⁸ found that in comparison to subjects who have never been smokers, former smokers were 20% more likely and current smokers were 50% more likely to report that musculoskeletal pain had prevented certain daily activities. However, Wilcox et al⁴⁴ did not find an association between smoking status and self-rated physical functioning among older adults with knee pain.

Dose-Response Relationships

A dose-response relationship between smoking and pain prevalence has been reported in some but not all studies for a range of bodily pains, with years smoked, number of packs per day, or pack/years typically used as the measure of tobacco dosage.^{2,12,33,34,46} When significant findings are reported, increased dose is associated with greater prevalence of pain. Consistent with this literature, we found several positive dose-response relationships. Among current smokers, the number of packs of cigarettes smoked per day was positively associated with 4 of 5 of the pain outcomes, with moderately small correlations ranging from .29 to .24. For smokeless tobacco, associations for duration and frequency of current use with oral pain were somewhat larger than those for

smoking, ranging from .37 to .32, and were found for temperature sensitivity, painful gums, and trouble with sleep.

In contrast to findings regarding tobacco and pain at non-oral sites, the duration of tobacco use among current smokers was negatively associated with several different markers of oral pain. To our knowledge this association has never been reported. The correlations were small but statistically significant, ranging from $-.28$ to $-.20$. Considering that only 4% of the current smokers had been smoking less than 10 years, we suggest the possibility of some long-term effect of tobacco on the oral cavity. Keep in mind that age at baseline was used as a covariate to limit confounds between age and duration.

There is some evidence that the smoking-pain link weakens in later years. For example, both Eriksen et al¹³ and Deyo and Bass¹² have reported that the relative risk of smoking on musculoskeletal pain prevalence was attenuated in older adults. To explore this association, we split the sample into 2 groups, those 45-64 years of age ($n = 95$) and those 65 years and older at baseline ($n = 27$). We found that in the older group, the largest correlation was between activity reduction and smoking duration ($r = -.23$) and was not statistically significant. However, within the 45- to 64-year age group, the correlations increased over those observed for the combined sample (temperature, $r = -.40$; tooth pain, $r = -.35$; activity reduction, $r = -.40$; trouble with sleep, $r = -.39$; all at $P < .05$). We can only speculate whether the association between tobacco use and oral pain diminishes with age or whether other factors begin to affect this relationship.

Implications and Conclusions

One of the consistent findings across our results was that the risk of painful oral symptoms and pain impact is reduced after cessation. Former users of tobacco were not different from those who have never been users in any of our analyses. This finding is consistent with several other studies in the pain and tobacco literature. For example, Scott et al³⁵ reported that associations between back pain and tobacco use were lower among former smokers than current smokers at similar levels of use. Although Palmer et al²⁸ did not find current smokers differed from former smokers for neck, shoulder, or back pain, they did find differences on measures of pain-related activity reduction. Unfortunately, many studies of tobacco and pain aggregate former and never users into a single category of "not currently using tobacco." Reduced risk after cessation might be less true for clinical markers of oral disease, because a recent review concluded that a similar risk of periodontal disease is carried over to former smokers.²¹

A number of reviews have documented that tobacco is a risk factor for the onset and/or exacerbation of oral diseases that are painful.^{21,22,45} Possible mechanisms include reduced salivary flow and caries,³⁴ impaired wound healing,²⁷ and exposure of root surfaces associated with periodontal disease.⁷ However, our findings

are likely to reflect factors other than but in addition to differences in oral disease progression. These other factors include a pharmacologic effect of tobacco (ie, nicotine) and psychological or sociocultural differences that might differ between those who become smokers and those who do not.

Long-term effects of smoking could be seen when assessing pain sensitivity according to smoking habits, but the findings have been mixed. In the Kaiser-Permanente Multiphasic Screening Program, smokers were less tolerant than nonsmokers of painful mechanical pressure,³⁶ but other studies have provided no evidence of a difference⁴³ or support the hypothesis that changes in pain perception reflect a direct pain-inhibitory effect of nicotine.^{29,31} An inhibitory effect on pain would be expected to decrease the report of oral pain. Smoking might also have local effects on pain sensitivity within the oral cavity that could be the result of acute or long-term exposure. However, no studies have directly examined pain sensitivity within the oral cavity as a function of duration or smoking status. There is one study that suggests oral pain might be masked by smokeless tobacco. In a study of oral tobacco cessation among Bangladeshi women, Croucher et al¹¹ reported that increased oral pain was reported as a barrier to successful cessation by 62% of the participants. Long-term changes that involve tissue damage or a prolonged resetting of the threshold for pain thresholds are better supported by the data than one that depends on transient pharmacologic effects.

Strengths of the current study include that we used several markers of tobacco use, which were prevalence, consumption, and duration, and we disaggregated current and former users. Unlike other studies of smoking and pain, we controlled for a range of potentially confounding variables including socioeconomic status, health care history, race, and sex. However, it should be noted that the pain-related variables are based on self-report and subject to an individual's interpretation. We did not assess the temporal sequence of cessation, so the diminished effect of tobacco use could not be documented, and we did not include a measure of pain intensity to model pain intensity across time.

This study reported epidemiologic data suggesting that current tobacco use is associated with an increased risk of experiencing a range of painful oral symptoms. We also found that behavioral impacts associated with oral pain are sensitive to differences in tobacco use status. No differences across any of the pain measures were found between former users and those who never used tobacco. The associations that we have described are moderate in size, and further investigations are needed to further examine the effects of tobacco on painful oral symptoms.

Acknowledgments

An Internet home page devoted to details about the FDCS can be found at <http://nersp.nerdc.ufl.edu/~gilbert/> (formerly <http://www.nerdc.ufl.edu/~gilbert/>).

References

1. Al-Wahadni A, Linden GJ: Dentine hypersensitivity in Jordanian dental attenders: A case control study. *J Clin Periodontol* 29:688-693, 2002
2. Andersson H, Ejlertsson G, Leden I: Widespread musculoskeletal chronic pain associated with smoking: An epidemiological study in a general rural population. *Scand J Rehabil Med* 30:185-191, 1998
3. Atchison KA, Gift HC: Perceived oral health in a diverse sample. *Adv Dent Res* 11:272-280, 1997
4. Bartecchi CE, MacKenzie TD, Schrier RW: The human costs of tobacco use. *N Engl J Med* 330:907-912, 1994
5. Beck JD, Koch GG, Offenbacher S: Incidence of attachment loss over 3 years in older adults: New and progressing lesions. *Community Dent Oral Epidemiol* 23:291-296, 1995
6. Beck JD, Sharp T, Koch GG, Offenbacher S: A 5-year study of attachment loss and tooth loss in community-dwelling older adults. *J Periodontal Res* 32:516-523, 1997
7. Bissada NF: Symptomatology and clinical features of hypersensitive teeth. *Arch Oral Biol* 39(Suppl):315-325, 1994
8. Chibnall JT, Tait RC: The Pain Disability Index: Factor structure and normative data. *Arch Phys Med Rehabil* 75:1082-1086, 1994
9. Cohen J: *Statistical power analysis for the behavioral sciences* (2nd ed). Hillsdale, NJ, Lawrence Earlbaum Associates, 1988
10. Creath CJ, Cutter G, Bradley DH, Wright JT: Oral leukoplakia and adolescent smokeless tobacco use. *Oral Surg Oral Med Oral Pathol* 72:35-41, 1991
11. Croucher R, Islam S, Jarvis MJ, Garrett M, Rahman R, Shajahan S, Howells G: Oral tobacco cessation with UK resident Bangladeshi women: A community pilot investigation. *Health Educ Res* 18:216-223, 2003
12. Deyo RA, Bass JE: Lifestyle and low back pain: The influence of smoking and obesity. *Spine* 14:501-506, 1989
13. Eriksen WB, Brage S, Bruusgaard D: Does smoking aggravate musculoskeletal pain? *Scand J Rheumatol* 26:49-54, 1997
14. Gilbert GH, Duncan RP, Heft MW, Dolan TA, Vogel WB: Multidimensionality of oral health in dentate adults. *Med Care* 36:988-1001, 1998
15. Gilbert GH, Duncan RP, Kulley AM, Coward RT, Heft MW: Evaluation of bias and logistics in a survey of adults at increased risk for oral health decrements. *J Public Health Dent* 57:48-58, 1997
16. Giovino GA: Epidemiology of tobacco use in the United States. *Oncogene* 21:7326-7340, 2002
17. Giovino GA, Schooley MW, Zhu BP, Chrismon JH, Tomar SL, Peddicord JP, Merritt RK, Husten CG, Eriksen MP: Surveillance for selected tobacco-use behaviors: United States, 1900-1994. *MMWR CDC Surveill Summ* 43:1-43, 1994
18. Grady D, Greene J, Daniels TE, Ernster VL, Robertson PB, Hauck W, Greenspan D, Greenspan J, Silverman S Jr: Oral mucosal lesions found in smokeless tobacco users. *J Am Dent Assoc* 121:117-123, 1990
19. Grasser JA, Childers E: Prevalence of smokeless tobacco use and clinical oral leukoplakia in a military population. *Mil Med* 162:401-404, 1997
20. Hutchinson D, Shepstone L, Moots R, Lear JT, Lynch MP: Heavy cigarette smoking is strongly associated with rheumatoid arthritis (RA), particularly in patients without a family history of RA. *Ann Rheum Dis* 60:223-227, 2001
21. Johnson GK, Slach NA: Impact of tobacco use on periodontal status. *J Dent Educ* 65:313-321, 2001
22. Kinane DF, Chestnutt IG: Smoking and periodontal disease. *Crit Rev Oral Biol Med* 11:356-365, 2000
23. Krishnan E, Sokka T, Hannonen P: Smoking-gender interaction and risk for rheumatoid arthritis. *Arthritis Res Ther* 5:R158-162, 2003
24. Leboeuf-Yde C: Does smoking cause low back pain? A review of the epidemiologic literature for causality. *J Manipulative Physiol Ther* 18:237-243, 1995
25. Lindal E, Stefansson JG: Connection between smoking and back pain: Findings from an Icelandic general population study. *Scand J Rehabil Med* 28:33-38, 1996
26. Martin GC, Brown JP, Eifler CW, Houston GD: Oral leukoplakia status six weeks after cessation of smokeless tobacco use. *J Am Dent Assoc* 130:945-954, 1999
27. Meechan JG, Macgregor ID, Rogers SN, Hobson RS, Bate JP, Dennison M: The effect of smoking on immediate post-extraction socket filling with blood and on the incidence of painful socket. *Br J Oral Maxillofac Surg* 26:402-409, 1988
28. Palmer KT, Syddall H, Cooper C, Coggon D: Smoking and musculoskeletal disorders: Findings from a British national survey. *Ann Rheum Dis* 62:33-36, 2003
29. Pauli P, Rau H, Zhuang P, Brody S, Birbaumer N: Effects of smoking on thermal pain threshold in deprived and minimally-deprived habitual smokers. *Psychopharmacology (Berl)* 111:472-476, 1993
30. Rees JS, Addy M: A cross-sectional study of dentine hypersensitivity. *J Clin Periodontol* 29:997-1003, 2002
31. Rau H, Schweizer R, Zhuang P, Pauli P, Brody S, Larbig W, Heinle H, Muller M, Elbert T, Dworkin B, Birbaumer N: Cigarette smoking, blood lipids, and baroreceptor-modulated nociception. *Psychopharmacology (Berl)* 110:337-341, 1993
32. Riley JL 3rd, Gilbert GH: Orofacial pain symptoms: An interaction between age and sex. *Pain* 90:245-256, 2001
33. Saag KG, Cerhan JR, Kolluri S, Ohashi K, Hunninghake GW, Schwartz DA: Cigarette smoking and rheumatoid arthritis severity. *Ann Rheum Dis* 56:463-469, 1997
34. Sakki T, Knuuttila M: Controlled study of the association of smoking with lactobacilli, mutans streptococci and yeasts in saliva. *Eur J Oral Sci* 104:619-622, 1996
35. Scott SC, Goldberg MS, Mayo NE, Stock SR, Poitras B: The association between cigarette smoking and back pain in adults. *Spine* 24:1090-1098, 1999
36. Seltzer CC, Friedman GD, Seigelaub AB, Collen MF: Smoking habits and pain tolerance. *Arch Environ Health* 29:170-172, 1974
37. Sinusas K, Coroso JG, Sopher MD, Crabtree BF: Smokeless tobacco use and oral pathology in a professional baseball organization. *J Fam Pract* 34:713-718, 1992
38. Symmons DP: Epidemiology of rheumatoid arthritis: Determinants of onset, persistence and outcome. *Best Pract Res Clin Rheumatol* 16:707-722, 2002
39. Tomar SL, Asma S: Smoking-attributable periodontitis in

the United States: Findings from NHANES III—National Health and Nutrition Examination Survey. *J Periodontol* 71:743-751, 2000

40. Tomar SL, Winn DM, Swango PA, Giovino GA, Kleinman DV: Oral mucosal smokeless tobacco lesions among adolescents in the United States. *J Dent Res* 76:1277-1286, 1997

41. Unell L, Soderfeldt B, Halling A, Birkhed D: Explanatory models for clinically determined and symptom-reported caries indicators in an adult population. *Acta Odontol Scand* 57:132-138, 1999

42. Unruh AM: Gender variations in clinical pain experience. *Pain* 65:123-167, 1996

43. Waller D, Schalling D, Levander S, Edman G: Smoking, pain tolerance and physiological activation. *Psychopharmacology* 79:193-198, 1983

44. Wilcox S, Brenes GA, Levine D, Sevick MA, Shumaker SA, Craven T: Factors related to sleep disturbance in older adults experiencing knee pain or knee pain with radiographic evidence of knee osteoarthritis. *J Am Geriatr Soc* 48:1241-1251, 2000

45. Winn DM: Tobacco use and oral disease. *J Dent Educ* 65:306-312, 2001

46. Yunus MB, Arslan S, Aldag JC: Relationship between fibromyalgia features and smoking. *Scand J Rheumatol* 31:301-305, 2002