Periodontal Effects and Dental Caries Associated with Smokeless Tobacco Use

JANE A. WEINTRAUB, DDS, MPH
BRIAN A. BURT, BDS, MPH, PhD

Dr. Weintraub is an Assistant Professor and Dr. Burt is Professor and Director, Program in Dental Public Health, University of Michigan School of Public Health, Ann Arbor, MI 48109-2029.

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Tearsheet requests to Dr. Weintraub.

Synopsis

The prevalence of smokeless tobacco use has been increasing in the United States with concomitant social, medical, legal, and regulatory ramifications. This paper examines the association between the use of smokeless tobacco and the occurrence of periodontal disease and dental caries. Existing literature consists primarily of case reports and cross-sectional studies among teenagers.

The limited evidence suggests an association between smokeless tobacco use and gingival recession. There is insufficient evidence to support any associations between smokeless tobacco use and gingivitis, periodontitis, or dental caries. Methods to improve future epidemiologic research to examine possible associations between smokeless tobacco use and periodontal effects or dental caries are discussed.

SMOKELESS TOBACCO (ST) PRODUCTS come in two major forms, chewing tobacco and snuff. Chewing tobacco can be in the form of a plug which is a portion from a processed bar of tobacco, or a twist or a roll in which the cured leaves are rolled and braided, or looseleaf which is usually distributed in a pouch. Snuff is a powdered or finely cut form of tobacco. Additional sweeteners, flavorings, and additives may also be included in the ST products (*1*).

Within the past year, many statements have been made about the alleged dangers associated with the use of smokeless tobacco. According to a former American Dental Association president, "The oral hazards associated with snuff and other smokeless tobacco products are clear—oral cancer, irreversible gum damage, discolored teeth, bad breath, tooth abrasion, and cavities" (*2*).

An educational brochure produced by the American Cancer Society informs readers that health hazards from chewing tobacco and snuff include " . . . less sense of taste and ability to smell . . . dental problems such as receding gums, greater wear and tear on tooth enamel and more tooth decay. And like most tobacco users, more bad breath and discolored teeth" (*3*).

In 1985, warning labels for smokeless tobacco products were proposed in Congress. One suggested label was "WARNING: THIS PRODUCT MAY CAUSE GUM DISEASE AND TOOTH LOSS" (*4, 5*).

Because of political activity and growing interest among health organizations concerning this subject, the literature on the relationship between ST use and dental caries and periodontal diseases was reviewed. The questions which prompted this review are

1. Does the use of smokeless tobacco increase the risk of periodontal diseases, including gingival recession, gingivitis, and advanced periodontal disease?
2. What is the relation between use of smokeless tobacco and dental caries?

Periodontal Diseases

Published reports which address the relation between the use of smokeless tobacco products and periodontal disease consist of anecdotal information (*6, 7*), case reports (*8–16*), and results of dental surveys of school-age children (*17–21*).

Table 1. Summary of case reports of periodontal effects associated with smokeless tobacco (ST) use

Author	Users		Exposure	Years of use	Findings
	Number	Age (years)			
Christen et al. (*9*)	1	36	Snuff	13	Gingival recession, abrasion, gingivitis
Christen et al. (*10*)	14	[1]20	ST	4.79	8 of 14 had gingival recession
Croft (*11*)	1	54	ST	23	Gingival recession, gingivitis
Croft (*12*)	1	17	ST	5	Gingival recession
Belanger and Poulson (*8*)	2	11,15	Snuff	6	No gingival recession
Hoge and Kirkham (*14*)	1	20	Snuff	1	Gingival recession
Frithiof et al. (*13*)	1	42	Snuff	12	Gingival recession
Zitterbart et al. (*16*)	1	36	ST	24	Gingival recession, less severe gingivitis in areas adjacent to quid placement compared to other gingival areas

[1]Mean age.

Case reports are summarized in table 1. Of the 22 users who ranged in age from 11 to 54 and had a smokeless tobacco or specifically snuff habit ranging in duration from 1 to 24 years, 14 had gingival recession in the area of tobacco placement. The 2 youngest users in this group examined by Belanger and Poulson (*8*) and 6 of the 14 college students with a mean age of 20 years examined by Christen and coworkers (*10*) did not have gingival recession. Although Frithiof and colleagues (*13*) described in detail only 1 user with recession, they observed only 2 cases of gingival recession among the 21 men that they examined. These men, who had a mean age of 55 years and a mean duration of habit of 36.1 years, had been referred for treatment of "snuff-induced lesions in the oral mucosa."

In contrast to some of the other findings, Zitterbart and colleagues (*16*) found that the marginal gingivitis and calculus present in the anterior region of the oral cavity of a 36-year-old user were less severe than in the posterior area of quid placement. They suggested that use of ST "may actually decrease marginal gingivitis and calculus formation." It was not noted if conditions were also less severe in the other posterior areas.

The case report by Christen and co-workers (*9*) of a 36-year-old chronic 13-year snuff dipper is frequently cited in the ST literature. The four mandibular teeth adjacent to where the quid was placed were reported to have gingival recession as well as abrasion of the incisal and occlusal surfaces. Recession was especially severe on the cuspid which was found to have a three-walled bony defect on the distal surface and was subsequently extracted. This extraction appears to be the major basis of the claim of tooth loss from snuff use.

In 1965, Van Wyk (*15*) examined 50 oral lesions that he determined were caused by snuff in a study of snuff users among the South African Bantu. The snuff used in this population, however, is different from that used in the United States so his findings may not be comparable. He found a pattern of localized gingival recession and black stain on the teeth of users.

Studies with larger sample sizes are summarized in table 2.

The study conducted by Modeer and co-workers (*17*) included 232 Swedish children with a mean age of 13.5 years. Responses to interviews with the children indicated that 11 percent of the boys (13 boys) had regularly used snuff for an average of 3.5 hours per day. Using a stepwise regression analysis to predict gingival index scores, snuff-taking was a significant variable after controlling for plaque index scores. Thus, users and nonusers of snuff with similar levels of plaque still show differences in severity of gingivitis.

In the Colorado studies 1,119 teenagers ranging from 14–19 years in the metropolitan Denver area (*19*) and 445 teenagers, average age 16.7 years attending school in rural areas (*20*), were examined. In the urban group, 117 students were identified via a questionnaire as being ST users and, of these students, about half, 57 users, had some lesions in the area where the quid had been placed. Greer and Poulson (*19*) defined tobacco-associated periodontal effects as "site-specific gingival recession with apical migration of the gingiva to or beyond the cementoenamel junction, with or without clinical evidence of inflammation." Seven persons had gingival recession, and 23 had both periodontal and mucosal lesions. In the rural group, 35 of 56 boys who indicated that they used ST had some oral disease. Two members of this

Table 2. Summary of studies of periodontal effects associated with smokeless tobacco (ST) use

Author	Users		Exposure	Years of use	Findings
	Number	Mean age (years)			
Modeer et al. (*17*)	13	13.5	Snuff	2	Gingivitis
Greer and Poulson (*19*)	117	[1]14–19	ST	3.25	30 users had gingival recession, all in area of tobacco placement
Poulson et al. (*20*)	56	16.7	ST	3.5	15 users had gingival recession, all in area of tobacco placement
Offenbacher and Weathers (*21*)	75	13.8	ST	Over 2	45 users had gingival recession, only 3 instances in area of tobacco placement

[1]Age range.

group had developed gingival recession, and 13 had both periodontal and mucosal lesions. There was no evidence in the urban group of dental caries, advanced periodontal disease, occlusal and incisal abrasion, or tooth loss associated with relatively short-term use. The presence or absence of these conditions was not reported for the rural group.

All these studies were descriptive in nature. Users and nonusers of ST were not compared, and each subject was examined only once. Information was collected regarding the most recent dental visit and alcohol and cigarette habits, but differences among these small subsamples with different habits with respect to severity of lesions were not found.

The most complete study to date was conducted by Offenbacher and Weathers in Georgia (*21*). In this cross-sectional study, 565 boys with a mean age of 13.8 years were screened, and they completed a questionnaire regarding tobacco usage. Of the 175 boys who reported that they had tried ST, 75 indicated that they currently were ST users. About half of the current users had been using ST for 2 or more years beginning at about age 12. Frequency of use was not reported. Among the 75 users, 60 percent exhibited gingival recession ranging from 1–4 mm. Unlike the previous reports, only three instances of gingival recession at the site of tobacco placement were identified. It was not clear whether three persons were involved or three tooth sites. Among 490 nonusers, 14 percent had gingival recession. There was a significant association between ST use and gingival recession. There was no association between ST use and presence or absence of gingivitis. An analysis of ST use with other potential contributing factors found that users had an increased risk of gingival recession when they had coexisting gingivitis. The investigators hypothesized that existing gingival inflammation may make the tissues more susceptible to any injurious action of the ST products.

To summarize, the limited evidence available suggests that gingival recession may be associated wth ST use, particularly among those users with coexisting gingivitis. Most studies specifically reported recession only when it occurred in the area of tobacco placement, although Offenbacher and Weathers (*21*) found recession in other areas of the mouth as well. Because of the study design employed, a temporal sequence cannot be determined. There is insufficient information to determine whether ST use increases the risk of gingivitis or periodontitis. The larger studies to date have involved teenagers and relatively short-term use. If more severe periodontal disease is associated with ST use it would be more likely to occur, if at all, after long-term use.

Dental Caries

The literature associating ST use with either increasing or decreasing dental caries incidence is even more sparse than the literature associating ST with periodontal diseases, and it is more difficult to interpret. Theories have been postulated based on limited clinical findings, chemical analyses of the content of various ST products, and in vitro effects of ST on the growth of bacteria implicated in caries development.

Anecdotal evidence has associated ST use with both increased (*22*) or decreased (*23*) dental caries prevalence. In case reports, Croft (*11*) found cervical caries in the area of tobacco placement in his 54-year-old patient who also had gingivitis and recession in the same area. In contrast, Zitterbart and colleagues (*16*) did not find any evidence of caries or marginal gingivitis in the area of quid placement in their 36-year-old tobacco chewer.

The study of Swedish children (*17*) did not report dental caries prevalence among snuff users. In the study of Colorado youth (*19*), one instance of cervical erosion was reported in a patient who had periodontal and mucosal lesions in the same area of quid placement. The investigators, however, did not find any dental caries that they could attribute to ST use.

The Georgia study (*21*) compared the decayed, missing, and filled teeth (DMFT) rate of ST users and nonusers, with and without coexisting gingivitis, according to type of ST used. They concluded that ST users were at increased risk of higher DMFT scores if they had gingivitis. Users and nonusers without gingivitis did not have significantly different DMFT scores. Among those with gingivitis, users of both snuff and chewing tobacco had a higher DMFT rate, 6.56, than users of only snuff, 3.82, or only chewing tobacco, 3.95, although the sample sizes were small. Age-specific DMFT scores were not reported, although the age distribution of subjects ranged from 10 to 17 years, an age range where a large variability in DMFT scores would be expected. There was no difference among users and nonusers with respect to reported frequency of dental visits.

Chemical analyses of ST have shed little light on the subject. Going and colleagues (*24*) summarized some of the possible mechanisms whereby use of smokeless tobacco might inhibit caries formation: by affecting the microflora, by stimulating salivary flow, by mechanical action, or by the presence of small amounts of fluoride in the ST. Sweetened forms of tobacco might also act to promote caries by bathing the teeth in cariogenic sugars. Chemical analyses of various ST products have shown large variations in sugar concentrations in different forms of tobacco products, different brands, and in the same products sold in different States (*24–27*). Pouch and plug tobacco had a higher sugar content than snuff (*24–27*), pipes, or cigars (*24*). Among four popular brands of pouch and plug tobacco tested from 10 States, the sugar content ranged from 13.5 percent to 65.7 percent (*24*). Shannon and Trodahl (*27*) specifically analyzed percent sucrose and glucose content of pouch, plug, and powdered tobacco and found a smaller range, from 1.0 to 16.0 percent sucrose and 2.2 to 13.1 percent glucose among the pouch and plug tobacco brands tested. Pyles and colleagues (*26*) even warned that, if swallowed, the glucose in chewing tobacco could adversely affect blood glucose levels of diabetics.

In snuff, small or no detectable amounts of sucrose have been found (*25, 27*). According to Going and others (*24*), the mean total sugar contents of the two major brands of snuff were 1.6 and 1.7 percent.

Going and colleagues (*24*) found median fluoride content of the various forms to be plug 1.35 ppm, pouch 0.56 ppm, and snuff 0.18 ppm. The mean fluoride concentrations among the brands tested by Shannon and Trodahl (*27*) for plug, pouch, and snuff forms were up to 1.44 ppm higher.

The various ST products thus appear to have a wide variation in fluoride and sugar content. Plug and pouch forms of smokeless tobacco, however, tend to have higher concentrations of both sugar and fluoride compared to snuff, which has relatively low concentrations of both sugar and fluoride. The actual bioavailability of either the sugar or the fluoride is unknown.

Lindemeyer and others (28), in their in vitro studies, found that the sugar content of chewing tobaccos was sufficient, and of snuff, insufficient, to enhance the growth of *Streptococcus mutans* and *Streptococcus sanguis*. (*S. mutans* has been shown to be a major cariogenic organism (*29*).)

It is plausible that certain brands of chewing tobacco with a high sugar content could be cariogenic, especially when held in the mouth for long periods. The hypothesized role of stimulated saliva in mitigating this effect based on salivary flow, buffer capacity, and physical and chemical properties (*27*) is unclear.

It is difficult, therefore, to determine the role of ST in the development of caries. Most of the information that is available does not include presence or absence of confounding factors such as fluoride history and oral hygiene status. According to one study (*21*), coexisting gingivitis is necessary for ST to increase the risk of dental caries. There is insufficient information to conclude that ST has a causal role in either caries formation or inhibition.

Claims that ST causes bad breath, stained teeth, diminished taste acuity, or abrasion may be logical assumptions based on experience of tobacco smokers, or they may be based on clinicians' personal experiences with smokeless tobacco users. These claims may be true, but they cannot be substantially supported.

Discussion

Ideally, the best way to demonstrate an association between a hypothesized factor and disease is an experimental study in which the investigator has

control over as many experimental and confounding factors as possible and can determine the frequency and duration of the exposure (*30*). A clinical trial to study the relation between ST and periodontal diseases or dental caries has obvious ethical limitations since the use of ST is potentially harmful and addictive to subjects in the experimental group. It is therefore necessary to use a nonexperimental study design.

An important consideration in any study design would be the definition of a user. Doll and Hill (*31*) discussed this difficulty in their assessment of tobacco smokers; patterns of tobacco use, whether smokeless or smoked, may change over time in frequency and duration. There is a continuum of exposure status that is only as reliable as the subjects' recall ability and truthfulness. For example, according to an analysis conducted by Warner (*32*), self-reported cigarette consumption was only two-thirds of actual consumption for the U.S. adult population, as determined from national surveys and U.S. Department of Agriculture data. Adults may underestimate the extent of their tobacco habit.

The amount and the frequency of exposure as well as duration may also be critical. Poulson and others (*20*) found a significant difference in daily length of exposure between users who had developed oral lesions (205 minutes per day) and users who had not (110 minutes per day), although there was a wide range of duration for both these groups. Greer and Poulson (*19*) found a similar pattern. Hirsch and co-workers (*33*) calculated total exposure as the product of number of years of snuff habit, daily exposure to snuff in hours, and daily consumption of snuff in grams. The inclusion of the amount of snuff in addition to the frequency gives an indication of how often the quid is replaced or how much tobacco is used.

The next consideration is to determine the type of ST to which the subject is exposed. The different brands of ST products come in many shapes, sizes, and consistencies with varying contents. There are different botanical varieties of tobacco in addition to variations produced by location where the plant is grown and the manufacturing process used (*34*). Several investigators have reported exposure of patients to ST, but they did not specify what type of ST was used.

A third consideration would be to determine if the different exposure groups are similar with respect to other factors associated with periodontal diseases or dental caries. The groups would need to be analyzed with respect to oral hygiene status, toothbrushing habits and type of toothbrush used, dental care utilization, exposure to fluoride, age, sex, diet, use of other tobacco or smoking products, other oral habits, and socioeconomic status. Offenbacher and Weathers (*21*) also considered malocclusions and orthodontic appliances as potential factors related to gingival conditions. Frithiof and colleagues (*13*) have indicated that habitual use of snuff in some cultures is also associated with alcohol use, nutritional deficiencies, and irregular life patterns. Many of these factors are interrelated. It is also possible that ST use may not be an important risk factor when considered separately, but it may be a contributing or potentiating factor when combined with other factors.

If a case-control study is used to investigate the degree of ST exposure of those with and without oral disease, the disease should be well-defined for proper selection of cases. Gingivitis and periodontitis and dental caries can be localized at the area of tobacco placement or generalized throughout the mouth. If, for example, localized gingival recession is considered, the unit of analysis can be restricted to one tooth, one sextant, or one quadrant. Mean intraoral scores would mask local differences. If the mode of action is mechanical, then a definition in which the disease is localized might be appropriate. The possibility, however, of more than one frequently used site of quid placement in an individual must be taken into account. If the mode of action is primarily chemical, then the effects may be more generalized. Carious lesions on different types of tooth surfaces, especially occlusal surfaces that would be more susceptible to abrasion and root and buccal surfaces that would be in most direct contact with the tobacco, need to be considered separately.

Since teeth may be missing for many different reasons, including some that are not directly related to either disease entity, the investigator needs to determine how to consider missing teeth in the analysis. If anyone with some degree of gingivitis, periodontitis, or dental caries is considered a "case," then the majority of the adult population would be eligible. More specificity is needed. At the same time, a spectrum of host responses is expected because of a range of exposures and normal biological gradients.

Conclusions

1. The information available to determine if there are any associations between ST use and periodontal effects or dental caries is limited

primarily to case reports and a few cross-sectional studies among teenagers.

2. This limited evidence suggests an association between ST use and gingival recession.

3. No association between ST use and dental caries experience is supported by current evidence.

4. Research involving larger groups of long-term users and the collection of complete information regarding frequency and duration of exposure, and possible confounding or coexisting factors, is needed to determine if there are associations between ST use and gingivitis, periodontitis, or dental caries.

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