J Oral Pathol Med (2005) 34: 340–6

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Risk factors associated with denture stomatitis in the United States

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BACKGROUND: This study reports denture stomatitis (DS) prevalence from a large USA probability sample from the National Health and Nutrition Examination Survey, 1988–1994 (NHANES III).

METHODS: Oral examinations were performed on 3450 individuals 18–90+ years of age (mean: 59.2; SD: 0.50 years), 57.7% male and 42.3% female. Multivariable logistic regression models were fitted for DS using sociodemographic, denture quality, blood analytes, alcohol and tobacco use, history of diabetes, and current antibiotic use as covariates. Odds ratios (OR), adjusted for other covariates in each model (AOR) are presented.

RESULTS: Of 3450 removable denture wearers, 963 (27.9%) had DS. DS prevalence was associated with wearing maxillary (AOR: 6.20) and mandibular (AOR: 5.21) complete dentures continuously; smoking ≥15 cigarettes day (maxillary complete: AOR = 1.31; mandibular complete: AOR = 1.50; maxillary partial: AOR = 2.04); vitamin A deficiency (mandibular complete: AOR = 5.97; maxillary partial: AOR = 5.67; mandibular partial: AOR = 24.42). Maxillary dentures with inadequate relines had approximately half the OR of DS than those with adequate relines (maxillary complete: AOR = 0.42; mandibular complete: AOR = 0.50).

CONCLUSIONS: Denture stomatitis prevalence is associated with the amount of tissue covered by dentures, low vitamin A levels, cigarette smoking, and constant denture wear.

J Oral Pathol Med (2005) **34**: 340–6

Keywords: adverse effects; candidiasis; denture; immunology; National Health and Nutrition Examination Survey III; oral; oral medicine; saliva; smoking; stomatitis; vitamin A deficiency

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Accepted for publication September 15, 2004

Introduction

Denture stomatitis (DS) is a clinical diagnosis of an inflammatory lesion in which there is redness of the oral mucosa underneath a removable denture. It is believed that most cases of DS are *Candida*-related (1). *Candida* species are part of the usual flora of the mouth and *C. albicans* has been shown to form on acrylic surfaces (2).

Reports of DS prevalence, as well as that of other oral mucosal lesions (3), have generally been based on small or atypical samples, e.g. individuals in nursing homes (4), the non-institutionalized elderly or non-probability samples such as health fairs or dental school patients (5). Moreover, DS prevalence has frequently been reported using the entire sample (including non-denture wearers) (6) as the denominator rather than the removable denture wearers only. The resulting prevalence cannot be decoded unless the proportion of removable denture wearers is reported – as often it is not. Finally, the results are rarely stratified by or adjusted for etiologic factors believed to be associated with DS. While most studies report DS prevalence to be high among removable denture wearers, reported prevalence varies widely: 50.5% in a large Swedish probability sample (6); 72% among 146 elderly removable denture wearers living in a medical, geriatric institution (7); 14.3% of 252 Thai dental school patients 60 years of age and older (5).

Risk factors associated with oral candidiasis and DS are wearing complete (in contrast to partial) dentures (5); wearing a maxillary (in contrast to a mandibular) removable denture (8); inadequate denture hygiene (9, 10), nocturnal denture wear (11); poor denture quality (12); diabetes mellitus (13–15); antibiotic therapy (16); immune deficiencies (16), vitamin A (17), folate (18), and iron (19) deficiencies; impaired salivary gland function (20), xerogenic medication (21), tobacco use (11, 15, 22), salivary secretion rate (22), and gender (8).

While DS prevalence from the Third National Health and Nutrition Examination Survey 1988–1994 (NHANES III) in the general population has been reported (3) we focus on DS prevalence among removable denture wearers and explore risk factors suggested

in the literature taking advantage of the extensive health interview and laboratory data collected as part of NHANES III (23).

Materials and methods

Oral mucosal examinations were performed as part of NHANES III, a periodic survey conducted by the National Center for Health Statistics. Subjects from 19 528 randomly selected representative households nationwide were interviewed and examined in mobile examination centers and at home (23). Dentist examiners were trained to recognize oral mucosal lesions based on the World Health Organization's Guide to Epidemiology and Diagnosis of Oral Mucosal Diseases (24). A diagnosis of DS was made when inflammatory changes were identified beneath an removable denture and was categorized as types: (i) localized simple inflammation, with red spots usually around the small palatal salivary glands and diffuse inflammation of limited areas of the palatal mucosa; (ii) diffuse hyperemic mucosa extending over the entire denture-bearing area, with a smooth surface; and (iii) hyperemic mucosa with a papillary or nodular surface appearance usually localized to the central part of the hard palate (25). For a lesion to be classified as DS, there must be visible inflammatory changes under the denture (25). Patient-reported discomfort in the absence of inflammation was not recorded as DS. In addition, examiners mapped the areas affected by the lesion to one or more of 27 locations in the mouth (25). Although smears for yeast were taken, all diagnoses were clinical (25). Individuals with clinically apparent lesions asked if they were painful. In addition, complete denture wearers were asked how often they wore their dentures.

Our analysis focused on individuals who wore at least one removable denture. We explored the association of DS point prevalence with sociodemographic and clinical variables that the literature suggests may be associated with DS. Demographic variables comprised gender, race-ethnicity (non-Hispanic White, non-Hispanic Black, and Mexican-American), and age. Subjects not falling into the three race-ethnicity categories were excluded from analyses using the race-ethnicity variable resulting in the removal of 161 subjects categorized as 'other' from some analyses. Income was measured by the poverty income ratio (PIR) that relates family income to the poverty level based on the subject's family size (23). Low-income families had low PIR levels.

Clinical variables included removable denture type and quality; denture wearing patterns; current tobacco use, history of physician-diagnosed diabetes, reported alcohol consumption, current antibiotic, antimycotic, or corticosteroid use ≥3 days. Carbohydrate intake was derived from a 24-h diet diary obtained by interview. We classified subjects as being above or below the 90th percentile for carbohydrate intake (>415 g/day) of the 3450 subjects in the study.

Tobacco users were divided into the following groups: (i) cigarette, (ii) pipe, (iii) cigar smokers, and (iv) snuff/chewing tobacco users. Cigarette smoking was categorized as 0, 1–15, and more than 15 cigarettes smoked per day. For our analyses of the effects of tobacco products, subjects who concurrently used any other tobacco product were excluded. Serum levels of vitamins A and potential vitamin A precursors α- and β-carotene; vitamins B12, C, D, E, red blood cell (RBC) and serum folate; serum iron, ferritin, hemoglobin A1c, calcium were assayed from blood drawn at the time of examination.

Dentists assessed denture quality by removing the dentures and evaluating: (i) integrity (fractures, cracks, or holes in the base material; missing or chipped teeth; broken clasps, rests, or broken portions of the framework); (ii) evidence of excessive wear of posterior teeth (≥1/2 of premolars and molars lacking occlusal anatomy); (iii) the presence of patient-applied reline material or professionally applied tissue conditioner, or the presence of a denture adhesive; an assessment of (iv) stability (complete dentures that move 2 mm or more in any direction when the denture is manually moved laterally; partial denture occlusal rests or indirect retainers that move 1 mm or more when unilateral or bilateral forces are applied to the denture base); and (v) retention (the denture dislodges when the patient opens the mouth comfortably wide). The first three assessments were accomplished extraorally while the last two were made in the patient's mouth. Temporary partial dentures and totally tissue-borne all-resin prostheses were excluded (25, 26). Each removable denture was coded 1 (not acceptable) or 0 (acceptable).

Data analysis

Because the survey used complex, multistage sampling, SAS®-callable SUDAAN 8.0.2® was used to compute standard errors for all variables adjusting for the effects of the survey design (design effect) as well providing the (weighted) population size to which the prevalence data can be projected.

Mean laboratory analyte values between individuals with and without DS were compared using *t*-tests; and those with $P < 0.10$ were converted to categorical variables (deficient/not deficient) using diagnostic thresholds for deficiency: vitamin A (<30 μg/dL) (27); vitamin C (<0.1 mg/dL) (28); vitamin B12 (<100 pg/mL) (28); RBC folate (<150 ng/mL) (28). For α- and β-carotene, the 5th percentile of the adults in the NHANES III database (1.0 and 5.0 μg/dL, respectively) was used. Bivariate logistic regression was performed and variables with $P < 0.20$ (Wald F-statistic) were retained as candidates for a multivariable logistic regression model. Separate multivariable models were fitted for maxillary and mandibular complete dentures and partial dentures using forward selection, incrementally adding variables starting with the variable with highest Wald F-statistic, and proceeding to first and second order interactions. Statistically significant interactions were retained only when the corresponding main effects remained significant. Variables that did not meet the $P < 0.05$ retention criterion were removed. The multivariable models produce adjusted odds ratios (AOR) that take into account the simultaneous effects of the other covariates in the model.

Table 1 Denture stomatitis prevalence, standard error, by removable denture configuration

		Denture stomatitis					
		All types		*Types 1 and 2*		*Type 3*	
Denture configuration	*N*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Maxillary complete	604	34.4	2.92	19.6	2.00	14.8	2.59
Mandibular complete	21	2.8	3.12	2.8	3.12	0.0	0.00
Maxillary complete/mandibular complete	1519	25.6	1.56	14.4	1.24	11.2	1.23
Maxillary partial	503	33.7	3.77	22.2	3.77	11.5	2.14
Mandibular partial	197	2.6	1.57	0.6	0.59	2.0	1.48
Maxillary partial/mandibular partial	300	29.8	3.62	20.3	3.57	9.5	2.26
Maxillary complete/mandibular partial	296	29.0	3.78	22.8	3.22	6.3	3.21
Maxillary partial/mandibular complete	10	22.7	13.39	16.4	11.88	6.3	6.05
Total	3450	27.9	1.05	17.1	0.93	10.8	1.09

Results

The 3450 (18.8%) adults wearing at least one removable denture examined represent a population of approximately 34 million non-institutionalized US adults. The mean age was 59.2 (SD: 0.50) years and the denture wearers were 57.7% male. Lesions were present in 879 (27.9%) individuals. Positive smears for *Candida* sp. were found in 70 lesions (7.2%). None of the individuals with DS reported any pain. Of 2419 maxillary and 1550 mandibular complete dentures for which lesion location was recorded, 35.0 and 17.9%, respectively had DS. Similarly, of 813 maxillary and 793 mandibular partial dentures, 33.2 and 1.1%, respectively had DS.

Complete maxillary and maxillary partial dentures were associated with the greatest DS prevalence; 34.4% and 33.7%, respectively. Individuals with only a mandibular denture had the lowest DS prevalence (Table 1). Of the previously described laboratory analytes, only vitamin A, α- and β-carotene, serum and RBC folate, and vitamin C were significant at $P < 0.05$ (not in table).

Individuals 18–39 [OR: 1.62; 95% confidence interval (CI): 1.08–2.44] and 40–59 (OR: 1.43; 1.14–1.79) had higher OR of DS than those 60 years of age and older (data not in table). Smokers of 15 or more cigarettes per day had higher OR of DS (OR: 1.49; 1.21–1.84) than non-smokers. Individuals who wore maxillary (OR: 6.12; 3.42–10.94) and mandibular (OR: 4.91; 3.17–7.62) complete dentures all the time had substantially higher ORs of DS then those who wore them only when awake. Individuals wearing maxillary and mandibular removable dentures (OR: 13.38; 4.36–41.11) and mandibular removable dentures only (OR: 19.03; 5.63–64.36) had greater ORs of DS than those wearing a maxillary removable denture only. Individuals deficient in vitamin A (OR: 3.06; 1.43–6.56) had greater ORs of DS than those with normal vitamin A levels. Low α- (OR: 1.32; 1.05–1.65) and β-carotene (OR: 1.50; 1.03–2.20) levels were associated with higher ORs of DS. Gender, race-ethnicity, diabetes, glycemic control, taking antibiotics or steroids, folate balance, tobacco use other than cigarette smoking or vitamin C deficiency were not associated with DS.

Defects in denture teeth were associated with DS for wearers of maxillary (OR: 1.57) and mandibular complete (OR: 1.54) dentures (Table 2). Defects in stability were associated with DS for maxillary partial dentures (OR: 1.95) wearers. A defective reline was associated with lower OR of DS for wearers of maxillary (OR: 0.48) and mandibular complete (OR: 0.63) dentures. Inadequate retention was associated with higher OR of DS for maxillary and (OR: 2.05) mandibular complete (OR: 1.96); and mandibular partial (OR: 1.78) dentures. Denture integrity was not associated with DS.

Table 3 shows the final multivariable models for each removable denture type, AOR, and 95% CI for the OR. Individuals who wore their complete maxillary denture

Table 2 Denture stomatitis odds ratio (OR), and 95% confidence intervals (CI) for denture quality measures

	Maxillary		*Mandibular*	
	OR	*95% CI*	*OR*	*95% CI*
Complete dentures				
Integrity				
Not acceptable	1.26	0.85–1.87	1.40	0.81–2.41
Acceptable	1.00		1.00	
Denture teeth				
Not acceptable	1.57	1.20–2.05	1.54	1.01–2.35
Acceptable	1.00		1.00	
Stability				
Not acceptable	1.08	0.81–1.44	1.64	1.19–2.27
Acceptable	1.00		1.00	
Reline				
Not acceptable	0.48	0.32–0.71	0.63	0.40–0.97
Acceptable	1.00		1.00	
Retention				
Not acceptable	0.49	0.34–0.70	1.96	1.40–2.76
Acceptable	1.00		1.00	
Partial dentures				
Integrity				
Not acceptable	0.97	0.61–1.53	0.81	0.37–1.80
Acceptable	1.00		1.00	
Denture teeth				
Not acceptable	1.48	0.81–2.70	1.30	0.78–2.14
Acceptable	1.00		1.00	
Stability				
Not acceptable	1.95	1.13–3.38	1.27	0.79–2.04
Acceptable	1.00		1.00	
Reline				
Not acceptable	1.42	0.50–4.02	0.51	0.14–1.92
Acceptable	1.00		1.00	
Retention				
Not acceptable	1.09	0.53–2.27	1.78	1.00–3.15
Acceptable	1.00		1.00	

Table 3 Multivariable logistic models for denture stomatitis prevalence for removable dentures: adjusted odds ratio, and 95% confidence limits

	Removable denture type							
	Column A (maxillary complete)		*Column B (mandibular complete)*		*Column C (maxillary partial)*		*Column D (mandibular partial)*	
Covariates	*AOR*	*95% CI*	*AOR*	*95% CI*	*AOR*	*95% CI*	*AOR*	*95% CI*
Denture wear								
All the time	6.20	3.52–10.92	5.21	2.94–9.24				
Only when awake	1.00		1.00					
Only occasionally	0.15	0.02–1.14	0.34	0.09–1.36				
Vitamin A deficiency								
Yes			5.97	1.79–19.90	5.67	1.59–20.29	24.42	5.77–103.33
No			1.00		1.00		1.00	
Reline								
Not acceptable	0.42	0.28–0.65	0.50	0.32–0.77				
Acceptable	1.00		1.00					
Retention								
Not acceptable			2.34	1.58–3.45				
Acceptable			1.00					
Stability								
Not acceptable					2.12	1.15–3.91		
Acceptable					1.00			
Teeth								
Not acceptable	1.46	1.11–1.93						
Acceptable	1.00							
Cigarettes/day								
0	1.00		1.00		1.00			
1–14	1.77	1.01–3.09	0.74	0.46–1.19	0.88	0.53–1.46		
≥15	1.31	1.03–1.67	1.50	1.05–2.16	2.04	1.10–3.82		
Age								
18–39					2.55	1.32–4.93		
40–59					1.20	0.69–2.10		
≥60					1.00			

(column A) all the time had more than six times the OR of DS (AOR: 6.20) as those who wore them only when awake. Dentures with inadequate teeth (AOR: 1.46) and smokers of ≥15 cigarettes/day (AOR: 1.31) were associated with DS. Wearing a denture with inadequate reline material was associated with less than half the OR (AOR: 0.42) of DS.

Individuals wearing a mandibular complete denture all the time (column B) had substantially greater OR of DS then those wearing them only when awake (AOR: 5.97). Wearing a mandibular complete denture with inadequate reline material was associated with an half the OR (AOR: 0.50) of DS. Poor retention was associated with increased OR of DS (AOR: 2.34). Smoking 15 or more cigarettes per day was associated with somewhat higher OR of DS (AOR: 1.50). Individual deficient in vitamin A had more than five times the OR (AOR: 5.97) of DS than those with normal vitamin A levels.

Individuals wearing a maxillary partial denture (column C) with inadequate stability was associated with greater than twice the risk of DS (AOR: 2.12). Smokers of 15 or more cigarettes per day (AOR: 2.04) and individuals 18–39 years of age (AOR: 2.55) had higher OR of DS. Individuals deficient in vitamin A had more than five times the OR (AOR: 5.67) of DS than those with normal vitamin A levels. Individuals wearing a mandibular partial denture who were deficient in vitamin A had more than 20 times the OR (AOR: 20.60) of DS than those with normal vitamin A levels.

Discussion

Candida fungi are ubiquitous microorganisms and opportunistic pathogens commonly found in the oral cavity of asymptomatic individuals (2). In health and in a normal local environment the host's defense systems prevent overt infection. There is some evidence that oral epithelial cells may present an innate defense response to *Candida* through the release of cathelicidins and defensins (29) for topical defense (30). Oral epithelial cells from healthy donors are reported to inhibit growth of several *Candida* species with cell contact being a strict requirement (31). In this *in vitro* study, whole unstimulated saliva showed some *Candida* growth inhibition but did not contribute significantly when combined with epithelial cells.

Our finding that individuals who wore their complete denture day and night had more DS than those who wore them only when awake has been reported (11, 32). This finding may be explained by the concept that when dentures are worn in this fashion the beneficial effects from the saliva (18, 22) are not present. Salivary components and the cleansing action of the tongue are a part of the hosts defense balance. The isolation of oral tissues under a denture, specially a large area under a complete maxillary denture that seals and forms its own microenvironment represents a local alteration that disturbs the normal balance.

In addition to the effect of the amount of time dentures are worn, our data suggest that DS is

associated with the amount of tissue covered by a denture. DS prevalence is higher in complete maxillary denture (34.4%) and maxillary partial dentures (33.7%); a findings consistent with those of Pires et al. (8) Consequently, the more surface (and *a fortiori*, the more surface not in contact with saliva), the greater the likelihood of DS.

Evidence of this is indirectly given by a study where antimycotic systemic medication was used to treat DS with some improvement, which showed relapse after the discontinuation of the drug (33), and by studies that deal with denture cleanliness where there is improvement in oral health after removing and cleaning of dentures (34, 35). Further indirect evidence of the effect from our findings, patients with maxillary and mandibular dentures with inadequate relines had lower OR of DS than those with acceptable relines. The protective effect of inadequate relines has not been described previously. Of the other dimensions of denture quality, only retention (mandibular complete denture: AOR = 2.12), stability (maxillary partial denture: AOR = 2.12), and tooth quality (complete maxillary denture: AOR = 1.46) are significantly associated with DS. Thus, our data support the hypothesis that contact with saliva is protective against DS.

Cigarette smoking

Heavy (≥15 cigarettes/day) smokers wearing maxillary complete, mandibular complete, and maxillary partial dentures had increased OR of DS (AORs: 1.31; 1.50–2.04, respectively); although it was not statistically significant for mandibular partial dentures. This is consistent with the previously suggested hypothesis that DS risk is associated with the amount of tissue coverage under which *Candida* biofilm can remain undisturbed. Our findings are consistent with those of Barbeau et al. (11) but contradict those of Guggenheimer et al. (14), Espinosa et al. (32), and Celic et al. (36). Interestingly, cigarette smoke has been associated with lowered levels of vitamin A (37).

Vitamin deficiency

It has been reported that hypovitaminosis A may play a role in mucocutaneous candidiasis through a possible alteration of the keratinization process (17). There is ample evidence that vitamin A: (i) is necessary for the maintenance of integrity of epithelial tissues, (ii) influences the immune response, (iii) is required for optimal maintenance and functioning of the immune system, and (iv) has an anti-inflammatory effect (38). Moreover, there is evidence that vitamin A inhibits translocation of the transcription nuclear factor kappa-B which is involved in the downstream synthesis of proinflammatory cytokines-like tumor necrosis factor-α thus lowering the inflammatory response (39) and that T-lymphocyte proliferation and cell cycle machinery are stimulated by vitamin A (40). These mechanisms are central to the immune response involved in the hosts defense balance. Our findings indicate a significant association between vitamin A deficiency and DS (AORs > 5) for all but maxillary complete dentures. While the association between maxillary complete dentures and DS was not statistically significant (AOR: 2.61; 95% CI: 0.55–12.45 – not in table), its direction was consistent with that of the other multivariable models. Perhaps our model did not have sufficient statistical power to find a significant difference.

While we found a significant difference in mean vitamin C, α- and β-carotene levels between subjects without DS compared to those with DS, the associations between having DS and being below the 5th percentile of α- and β-carotene was statistically significant; and the DS–vitamin C relationship was marginally significant in the bivariate analysis (not shown) but they did not meet the retention criterion in any of the multivariable models. It is likely that their influence of α- and β-carotene was overshadowed by that of vitamin A.

Sociodemographic factors

We found that while females had higher DS prevalence than males, it was not statistically significant. This conflicts with the findings of Pires et al. (8) who found that women had higher DS prevalence. Perhaps previous results were due to the lack of control for the effects of covariates (i.e. denture wearing patterns, smoking, denture quality, vitamin A deficiency).

Medication, diet, and comorbidities

We found no association between current antibiotic therapy and DS as suggested by Rossie and Gugg (16) in either the bivariate (OR: 1.46; 95% CI: 0.88–2.40 – not in table) or multivariable analysis. However, only 142 individuals were taking antibiotics for 3 or more days and the power of the analysis was likely low. Similarly, we found no association between alcohol intake or corticosteroid therapy and DS.

We did not find an association with diabetes, and glycemic control that has been found by others (13, 14). Individuals who reported that they had been told by a physician that they had diabetes did not have significantly different DS prevalence than those without a diabetes history. These individuals with a diabetes history comprised a wide range of disease severity which may have affected the analysis. Similarly, our carbohydrate intake data was based on a 24-h diet diary, which might have been subject to recall bias in the direction of underreporting carbohydrate intake. While individuals with glycosylated hemoglobin >9% had higher DS prevalence (OR: 1.53), the difference was not statistically significant.

Limitations

While NHANES III is based on a national probability sample and clinical data were collected by trained dentist-examiners using standard criteria for defining DS, there was no calibration (as there was with the decayed, missing and filled tooth surfaces (DMF) component). However, experienced dentists using well-defined diagnostic criteria should be reasonably consistent in identifying DS. Further, NHANES III is cross-sectional and may be used to explore associations,

not causality. Consequently, these findings must be viewed carefully. Epidemiologically significant relationships are the first step indicating that there should be further study, preferably using experimental interventional studies.

Despite the large number (16 883) of adults 18 years of age and older who received oral mucosal examinations and the high DS prevalence (27.9%) in the 3450 removable denture wearers, the statistical power of our multivariable analyses was low; especially in models with several low-prevalence covariates such as use of smokeless tobacco ($n = 39$), cigar ($n = 3$), and pipe smoking ($n = 8$), glycosylated hemoglobin $>9\%$ ($n = 430$), low vitamin A ($n = 328$), corticosteroid use ($n = 246$).

Conclusion

More than one quarter of removable denture wearers had DS. This suggests that *Candida*, although present, may not produce a clinical infection in many more removable denture wearers. Patients should be advised to use a denture cleanser that can eliminate *Candida* biofilm daily and remove their dentures at night. To elucidate the possible role of vitamin A, it would be interesting to examine the levels of vitamin A in patients who develop DS after topical treatment with steroids; and in other populations. Moreover, the effect of vitamin A supplementation on healing and recurrence in individuals with DS found deficient in vitamin A should be studied. While our findings that low levels of vitamin A are associated with DS have yet to be confirmed, chronic DS patients whose diet appears to be low in foods containing vitamin A should be advised to use vitamin supplementation. Finally, studies of DS based on bivariate analyses should be viewed skeptically because often bivariate relationships are either spurious or explained better by a combination of variables.

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