BRIEF REPORT

Associations of Depressive and Anxiety Disorders with Periodontal Disease Prevalence in Young Adults: Analysis of 1999–2004 National Health and Nutrition Examination Survey (NHANES) Data

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Abstract

Background Depression and anxiety have been linked to periodontal disease, an emerging risk factor for chronic diseases. However, this literature is mixed, and few studies have concurrently evaluated depression and anxiety.
Purpose We simultaneously examined the associations of depressive and anxiety disorders with periodontal disease prevalence and explored tobacco use as a mediator.
Methods Participants were 1,979 young adults from the National Health and Nutrition Examination Survey 1999–2004 who underwent a diagnostic interview and a dental examination.
Results Adults with panic disorder had a threefold higher odds of having periodontal disease than those without this disorder (OR=3.07, 95 % CI 1.17–8.02). This relationship was partially mediated by tobacco use and remained after adjustment for major depressive disorder and generalized anxiety disorder, which were not related to periodontal disease.
Conclusions Young adults with panic disorder may have greater odds of having periodontal disease, in part, due to increased tobacco use.

Keywords Panic disorder · Major depressive disorder · Generalized anxiety disorder · Periodontal disease · Tobacco use · NHANES

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Introduction

Periodontal disease is a cluster of inflammatory conditions in which bacterial infections affect the tissues connecting the teeth to the underlying bone structure and elicit an inflammatory response, which ultimately leads to tissue breakdown and tooth loss [1]. Although the high prevalence of periodontal disease (8.5 % among American adults) indicates that it is a serious public health concern in its own right [2], evidence suggests that it is an emerging risk factor for several chronic diseases with an inflammatory component, including cardiovascular disease, type 2 diabetes, Alzheimer's disease, and certain cancers [3]. In addition, a growing body of evidence indicates that periodontal disease may be associated with poor mental health, in particular depression and anxiety. This literature, however, is mixed, with multiple studies reporting a positive association [4–6] and others observing no such link [7, 8]. Therefore, it is unclear whether a replicable association exists between depression or anxiety and periodontal disease.

Methodological weaknesses of past investigations may account for the discrepant results [4]. First, most studies have utilized self-report measures to assess depression and anxiety, which may not capture clinical levels of symptomatology and may have reduced specificity [9]. Second, only a handful of studies have concurrently examined depressive and anxiety symptoms [6–8, 10, 11]. Given the high comorbidity between depressive and anxiety disorders [12] and the moderate to large correlations between depressive and anxiety symptom measures [13], it is unclear whether depression, anxiety, or both are independently associated with periodontal disease. Similarly, it is not known whether particular anxiety disorders, which are also highly comorbid [12], are more strongly related to periodontal disease than are others. Our objective was to address these limitations by

simultaneously examining the associations of major depressive disorder, generalized anxiety disorder, and panic disorder with periodontal disease prevalence in a sample of young adults representative of the US population. We also explored tobacco use as a mediator, as it is among the leading candidate mechanisms of the depression/anxiety–periodontal disease link [14].

Method

Sample and Procedure

The NHANES public use data files from 1999 to 2004 (www.cdc.gov/nchs/nhanes.htm) were examined. A description of the survey design—a stratified, multistage, probability sample—is available elsewhere [15]. Participants first completed an interview in their homes. Additional interviews and all examinations, including the mental health and dental examinations, were conducted in mobile examination centers after the home interview [15]. A total of 31,126 individuals participated in the 1999–2004 surveys. For several variables, data were collected from only a smaller subsample, which remained representative of the US population [15]. Of relevance, a subsample of 2,556 adults aged 20–39 years was selected for the mental health examination, 2,215 of whom had complete data for the mental health variables. Of these individuals, 1,982 were eligible for the dental examination and had complete periodontal data. We excluded three persons due to missing education data, leaving a final sample of 1,979 adults.

Measures

Depressive and Anxiety Disorders

During the mental health examination, the major depressive disorder, generalized anxiety disorder, and panic disorder modules of the World Health Organization Composite International Diagnostic Interview, auto version 2.1 (CIDI-Auto; [16]) were administered. The CIDI-Auto is an automated interview that provides psychiatric diagnoses according to International Classification of Diseases [17] and Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; [18]) definitions. The CIDI-Auto is appropriate for large epidemiologic studies because it (a) can be administered by lay interviewers, (b) does not require outside informants or medical records, and (c) does not assume the presence of a current disorder [19]. Although some data suggest that agreement between the CIDI-Auto and psychiatrists' diagnoses may be low ($\kappa < 0.40$) [20], the κ coefficient has been criticized because it underestimates concordance when the disorder base rate is low [21]. The area under the

receiver operating characteristic curve (AUC) metric, which is not dependent on base rate, indicates good concordance between past-year CIDI and Structured Clinical Interview for DSM-IV [22] diagnoses for mood (AUC=0.83) and anxiety (AUC=0.88) disorders [21]. Responses to CIDI-Auto questions were evaluated using computer algorithms [19]. If all criteria for a particular diagnosis were met, the individual was considered to have that diagnosis in the past year.

Periodontal Disease

Standardized dental examinations were conducted at the mobile examination centers by licensed dentists [23]. For survey years 1999–2000, two sites, the midbuccal and mesiobuccal, were examined for each tooth in two randomly chosen quadrants, one maxillary and one mandibular. For survey years 2001–2004, a third (distobuccal) site was added; however, we did not utilize these data because they were not available for 1999–2000. The assumption underlying this sampling procedure is that the status of the selected sites is representative of the health of the remaining teeth [24]. Periodontal disease is assessed by quantifying the extent of destruction of the periodontal supporting tissues, and the best indicator of this tissue destruction is loss of attachment (i.e., the distance from the junction of the crown and root to the base of the existing gap between the supporting tissues and tooth) [24]. We identified individuals with periodontal disease by using the Healthy People 2010 definition of one or more tooth sites with loss of attachment ≥4 mm [25]. This definition, developed by the US Department of Health and Human Services in collaboration with the CDC, is critical for monitoring the periodontal status of the US population over time and for evaluating Healthy People objectives [25].

Other Factors

The following variables were also included in our analyses: age, sex, race–ethnicity, education level, history of diabetes, and current pregnancy as potential confounders and tobacco use as a potential mediator (see notes to Table 1 for variable coding). During the home interview, participants reported their highest grade or level of school completed, which was used to create a five-level variable. Participants who reported during the home interview that a health professional had told them that they have diabetes (other than during pregnancy) were coded as having a history of diabetes. Women who indicated that they were pregnant during the home interview or had a positive pregnancy test during the mobile examination center assessment were coded as being currently pregnant. Tobacco use was computed from questions inquiring about the use

Table 1 Logistic regression analyses examining the association of major depressive disorder, generalized anxiety disorder, and panic disorder with periodontal disease

	Unadjusted models OR (95 % CI)	Confounder-adjusted models[a] OR (95 % CI)
Major depressive disorder	1.21 (0.60–2.43)	0.92 (0.42–2.02)
Generalized anxiety disorder	1.33 (0.37–4.80)	0.68 (0.21–2.21)
Panic disorder	3.07* (1.17–8.02)	3.09* (1.08–8.86)

$N=1,979$. Major depressive disorder, generalized anxiety disorder, panic disorder, and periodontal disease are all coded as 0 = no, 1 = yes

*$p<0.05$

[a] Adjusted for age (years), sex (0 = male, 1 = female), race–ethnicity (0 = white, 1 = non-White), education level (less than 9th grade; 9–12th grade with no diploma; high school graduate, GED, or equivalent; some college or associate degree; college graduate or above), diabetes (0 = no, 1 = yes), and pregnancy (0 = no, 1 = yes)

of cigarettes, cigars, chewing tobacco, pipe, and snuff. Individuals were coded as current users (current use of ≥1 tobacco products), former users (lifetime but no current use), or never users.

Data Analysis

To determine whether depressive and anxiety disorders are associated with periodontal disease prevalence, we conducted a series of unadjusted logistic regression analyses. First, major depressive disorder, generalized anxiety disorder, and panic disorder were entered as independent variables into separate models predicting periodontal disease. The three independent variables were then entered simultaneously into the same model. To evaluate the influence of potential confounders, we repeated the logistic regression analyses including age, sex, race–ethnicity, education, diabetes, and pregnancy (as a set) in each model. These variables were examined as potential confounders because they have previously been associated with depression, anxiety, and periodontal disease [18, 26].

To examine the effect of tobacco use on any observed relationships, we added this variable to the confounder-adjusted model. Percent change in effect size after adjustment for tobacco use was computed as $(B_{adjusted} - B_{unadjusted})/B_{unadjusted} \times 100$, where $B_{adjusted}$ is the unstandardized coefficient for the depressive/anxiety disorder variable from the confounder-adjusted model with tobacco use and $B_{unadjusted}$ is the same coefficient from the confounder-adjusted model. We also conducted Sobel tests [27] to assess whether tobacco use statistically mediated any observed association. All estimates from the logistic regressions were weighted using NHANES examination sample weights, which account for the complex survey design, survey nonresponse, and post-stratification [28], thereby yielding estimates representative of the US civilian, non-institutionalized population. We used SAS statistical software (version 9.3).

Results

In this sample of young adults ($M\pm SD$ age$=29.1\pm5.8$ years, 55 % female, 54 % non-White), there were 129 (6.5 %) cases of past-year major depressive disorder, 46 (2.3 %) cases of past-year generalized anxiety disorder, 41 (2.1 %) cases of past-year panic disorder, and 125 (6.3 %) cases of periodontal disease. Twenty-nine (23 %) individuals with major depressive disorder also met diagnostic criteria for generalized anxiety disorder or panic disorder. Of note, 25 % of our sample had less than a high school education, 2 % had a history of diabetes, 15 % were pregnant, 29 % were current tobacco users, and 16 % were former tobacco users.

Unadjusted logistic regression analyses (see Table 1) revealed that periodontal disease prevalence did not differ between adults with and without major depressive disorder (9.3 vs. 6.1 %, $p=0.60$) or those with and without generalized anxiety disorder (8.7 vs. 6.3 %, $p=0.66$). In contrast, individuals with panic disorder had a threefold higher odds of having periodontal disease than those without this disorder (14.6 vs. 6.1 %, $p=0.02$). The model in which the three depressive and anxiety disorder variables were simultaneously entered confirmed these results; the odds ratio for panic disorder, although falling short of significance, was not attenuated (OR$=3.28$, 95 % CI 0.87–12.34, $p=0.07$) and the odds ratios for major depressive disorder (OR$=0.94$, 95 % CI 0.38–2.30, $p=0.89$) and generalized anxiety disorder (OR$=0.89$, 95 % CI 0.15–5.30, $p=0.89$) remained near 1.0. The pattern of results was comparable after adjustment for the potential confounders (see Table 1). The simultaneous entry model also yielded similar results (panic disorder: OR$=4.41$, 95 % CI 1.17–16.64, $p=0.03$; major depressive disorder: OR$=0.79$, 95 % CI 0.31–1.97, $p=0.61$; generalized anxiety disorder: OR$=0.48$, 95 % CI 0.10–2.32, $p=0.36$).

When the tobacco use variables—current vs. never user and former vs. never user—were added to the confounder-adjusted model, the effect size of panic disorder was reduced

by 18 % (OR=2.53, 95 % CI 0.86–7.49, p=0.09). Sobel tests confirmed that current tobacco use (current vs. never user z=2.13, p=0.03), but not former use (former vs. never user z=0.22, p=0.83), was a partial mediator of the panic disorder–periodontal disease relationship. Consistent with this finding, current smoking was more prevalent among adults with versus without panic disorder (65.9 vs. 28.7 %; χ^2=26.69, p<0.001). The independent correlates of periodontal disease in the final model were age (OR=1.18, 95 % CI 1.14–1.23, p<0.01), education level (OR=0.63, 95 % CI 0.52–0.77, p<0.01), diabetes (OR=3.49, 95 % CI 1.14–10.67, p=0.03), and current vs. never tobacco user (OR=1.79, 95 % CI 1.12–2.89, p=0.02).

Discussion

In a sample of young adults representative of the US population, we found that individuals with panic disorder in the past year had a threefold higher odds of having periodontal disease than those without this disorder. This relationship remained after adjustment for comorbid depressive and anxiety disorders, suggesting that the symptoms of panic disorder that do not overlap with major depressive disorder and generalized anxiety disorder (e.g., panic attacks and agoraphobia) may be driving the observed association. Our analyses also revealed that current tobacco use partially mediated the panic disorder–periodontal disease relationship. In contrast to panic disorder, past-year major depressive disorder and generalized anxiety disorder were not associated with periodontal disease prevalence. Our findings raise the possibility that panic disorder, but perhaps not major depressive disorder or generalized anxiety disorder, may increase the risk of periodontal disease.

To our knowledge, this is the first study to examine the association between panic disorder and periodontal disease. Our results are partially consistent with those of Vettore and colleagues [4], as they found that greater anxiety symptom severity was associated with higher loss of attachment scores among 79 periodontal patients. Our findings are also partially consistent with those of Castro and colleagues [7], who found that depression symptom severity was not associated with periodontal indicators in a sample of 165 adults. On the other hand, our results conflict with those of Monteiro da Silva et al. [11], who reported that depressive symptoms, but not anxiety symptoms, were associated with greater periodontal disease severity. Taken together, these studies highlight the lack of consensus in the literature.

Behavioral factors may explain the panic disorder–periodontal disease association we detected. For instance, we found that current tobacco use accounted for nearly a fifth of

this relationship and was more than twice as common among individuals with panic disorder versus those without the condition. These findings suggests that the elevated prevalence of periodontal disease in adults with panic disorder may be partly due to their greater tobacco use, perhaps as an attempt to cope with symptoms [29]. Although not examined in our study, it is also possible that agoraphobia associated with panic disorder may limit one's mobility [30], which could lead to a reluctance to make routine dental appointments and a higher rate of missed appointments that are scheduled [30]. The resultant neglect of oral hygiene could promote periodontal disease [14]. Other candidate mechanisms include an unhealthy diet [14] and downregulation of the cellular immune response due to the increased release of hormones from the hypothalamic–pituitary–adrenal axis, neuropeptides from sensory nerve fibers, and epinephrine and norepinephrine from the sympathetic nervous system [14]. Future prospective studies assessing multiple candidate mediators are needed to elucidate the underlying mechanisms.

Our study has key strengths (e.g., a representative sample and a diagnostic interview); however, there are also limitations. The first limitation is the cross-sectional nature of the data, which cannot eliminate the possibility of reverse causality. The issue warrants attention, given that periodontal disease has been linked to bleeding, infection, difficulty chewing, and tooth loss [31]. These experiences could result in social anxiety, pain, and sleep disturbance, which have been shown to predict anxiety disorders and symptoms [32, 33]. The second limitation is that only two anxiety disorders were assessed and that the number of generalized anxiety and panic disorder cases was relatively low. To determine which anxiety disorders are the strongest predictors of periodontal disease, prospective studies that include assessments of all of the anxiety disorders are required. The third limitation is the restricted age range. As only adults 20–39 years were eligible for the mental health assessments, our results may not generalize to other age groups.

In summary, we found that the presence of panic disorder in the past year was associated with a higher prevalence of periodontal disease, whereas major depressive disorder and generalized anxiety disorder were not. Our results suggest that young adults with panic disorder may have a higher odds of periodontal disease and that this elevation in odds may be partly due to their increased tobacco use. Given that periodontal disease is a risk factor for multiple chronic diseases, the present findings also raise the possibility that periodontal disease may be one pathway through which panic disorder increases the risk of chronic diseases. If future prospective studies establish that panic disorder precedes and predicts periodontal disease, then interventions targeting panic disorder and/or the putative mediators

directly (e.g., tobacco use) could be employed to help prevent periodontal disease, an important public health concern and a risk factor for several of the leading causes of death of Americans [3].

Conflict of Interest The authors have no conflict of interest to disclose.

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