Original Research

Dental loss among ambulatory patients with diabetes

Kenneth E. Izuora [a,*], Echezona E. Ezeanolue [b], Michael F. Neubauer [c], Civon L. Gewelber [c], Gayle L. Allenback [d], Guillermo E. Umpierrez [e]

[a] Internal Medicine, University of Nevada School of Medicine – Las Vegas, 1701 West Charleston Boulevard, Suite 230, Las Vegas, NV 89102, USA
[b] School of Community Health Sciences, University of Nevada – Las Vegas, 4505 Maryland Parkway, Las Vegas, NV 89154, USA
[c] School of Dental Medicine, University of Nevada – Las Vegas, 1700 West Charleston Boulevard, Las Vegas, NV 89102, USA
[d] Office of Medical Research, University of Nevada School of Medicine – Las Vegas, Suite 290, 1701 West Charleston Boulevard, Las Vegas, NV 89102, USA
[e] Endocrinology, Emory University School of Medicine, 100 Woodruff Circle, Atlanta, GA 30322, USA

ARTICLE INFO

ABSTRACT

Aims: There is a high prevalence of dental loss among patients with diabetes. Understanding the factors that impact dental loss in this population will aid with developing new strategies for its prevention.
Methods: Using a cross-sectional study design, patients with diabetes presenting for routine clinic visit were evaluated with an investigator-administered questionnaire. Data were collected on demographics, dental history, duration, control and complications of diabetes.
Results: Among 202 subjects, 100 were female, mean age: 58.9 ± 13.2 years, duration of diabetes: 15.8 ± 11.0 years, and hemoglobin A1c: $7.7 \pm 1.6\%$. Thirty-one patients (15.3%) had lost all their teeth and only 13 patients (6.4%) had all 32 of their natural teeth. Using multiple linear regression, older age ($\beta = -0.146$; 95% CI: -0.062 to -0.230), not flossing ($\beta = -3.462$; 95% CI: -1.107 to -5.817), and presence of diabetic retinopathy ($\beta = -4.271$; 95% CI: -1.307 to -7.236) were significant predictors of dental loss.
Conclusions: Dental loss is common in patients with diabetes and is associated with older age, diabetic retinopathy and not flossing. In order to reduce dental loss among patients with diabetes, regular flossing should be emphasized as an important component of dental care.

Introduction

In the United States, the prevalence of diabetes in 2012 was more than 29 million [1,2]. Compared to their age-matched non-diabetic counterparts, patients with diabetes tend to lose their teeth earlier in life [3]. It is estimated that individuals with diabetes are 1.46 times more likely to have at least one tooth removed, when compared to those without diabetes [3]. In addition, patients with diabetes have poorer dental health practices and are less likely to have gone for a dental examination, when compared to non-diabetic patients [4,5].

The mechanism for the increase in dental loss among patients with diabetes likely relates to the increased incidence and severity of periodontal disease and dental caries among this population. Inflammation resulting from bacterial growth in periodontal plaque causes alveolar bone loss that ultimately results in the loss of teeth [6,7]. Regular dental care and good oral hygiene practices have been demonstrated to reduce the incidence of dental loss; however, there is inadequate emphasis on prevention and treatment for dental problems among medical providers caring for patients with diabetes.

The purpose of this study was to assess the prevalence of dental loss among our diabetes clinic patient population and to determine what clinical variables are associated with dental loss in this population.

Materials and methods

Subjects

The details of our study methods have been published previously [8]. In summary, this was a cross-sectional study of all patients with diabetes presenting for their routine care at a university outpatient clinic. We included all adult patients (age ≥ 18 years) who were willing to participate in the study. Informed consent and HIPAA authorization were obtained from all included participants.

Study procedures

Using a 48-item investigator-administered questionnaire [8], all subjects were interviewed to obtain information about their age, gender, body mass index (BMI), diabetes history (onset, use of insulin), diabetes control and complications (A1c, retinopathy, neuropathy, nephropathy, heart attack, stroke), dental care history (last visit to dentist, frequency of brushing, flossing and use of mouthwash), dental problems (loose teeth, bleeding while brushing, teeth sensitivity and number of teeth) and presence of osteoporosis (treatment for or history of osteoporotic fracture). We manually counted their teeth, and all questionnaire responses regarding the above clinical variables were verified from the patient's clinic chart. Questionnaire responses that were considered to suggest the presence of periodontal disease (i.e., gingivitis or periodontitis) included any positive answer to a history of deep cleaning, loose teeth, tooth sensitivity or gum bleeding when brushing. Patients were assigned unique study identification numbers and de-identified data were stored in a password-protected database.

Statistical analysis

Survey responses were summarized using means with standard deviations for continuous variables and using frequencies/percentages for categorical variables. The appropriate univariate analyses were done to ascertain the relationship between each surveyed variable and the number of remaining teeth (i.e., dental loss). For continuous survey variables, the appropriate univariate analyses included Pearson correlations; for categorical survey variables, the analyses included independent-samples t-tests and one-way ANOVAs. Suitable non-parametric tests were performed when indicated. Survey variables with significant association (p-values < 0.05) with number of remaining teeth were used to construct the multiple linear regression model for the prediction of degree of dental loss. The alpha value for statistical significance was set at $p < 0.05$, and all statistical analyses were performed using SPSS version 22.0 (IBM).

Results

Participants

A total 202 consecutive patients with diabetes were interviewed with an investigator-administered questionnaire during their routine clinic visit. Mean age and duration of diabetes were 58.85 ± 13.2 and 15.75 ± 11.0 years, respectively. Our population included 100 female (49.5%), 105 Caucasian (52.0%), 39 Hispanic (19.3%), and 35 African American (17.3%) subjects. Average BMI was 33.3 ± 8.2 kg/m³ and 67% were current or former smokers (Table 1).

Only 13 subjects (6.4%) had all their natural teeth, and 189 subjects (93.5%) were missing one or more of their natural teeth (31 subjects had no teeth, 32 had 1–16 teeth and 126 had 17–31 teeth; Fig. 1). Of those with teeth (n = 171), 87.7% had questionnaire responses suggestive of periodontal disease (Table 2).

Univariate analyses

Univariate analyses between each of the survey variables and number of teeth revealed that the following variables were significantly associated with the number of remaining teeth: age (in years), duration of diabetes (in years), smoking status (current/former vs. never), flossing, presence of retinopathy, presence of nephropathy, presence of neuropathy, presence of periodontal disease, and number of months since last visit to a dentist (Table 3).

Table 1
Characteristics of survey respondents, n = 202

	Mean (±SD), or number (%)
Demographics	
Age, in years	58.85 (±13.2)
Gender (female)	100 (49.5%)
Body mass index (BMI)	33.29 (±8.2)
Race (Caucasian)	105 (52.0%)
Diabetes (DM) status	
DM duration, in years	15.75 (±11.0)
Hemoglobin A1C, in %	7.67 (±1.6)
DM type (type 2)	176 (87.1%)
Dental status	
Number of teeth	19.63 (±11.1)
Last dentist visit, in months	39.01 (±79.1)
Have dental insurance	117 (57.9%)
Vascular complications	
Retinopathy	44 (21.8%)
Nephropathy	58 (28.9%)
Neuropathy	97 (48.0%)
Heart disease	39 (19.3%)
Stroke	29 (9.9%)
Other variables	
Current or former smoker	136 (67.4%)
Bone disease	36 (17.8%)

Regression model

Significant variables from the univariate analyses were included in the multiple linear regression model for the prediction of number of teeth remaining in a patient with diabetes (Table 4). This model was significant at p < 0.001 with an adjusted R^2 of 0.181. When adjusted for the other variables in this model (duration of
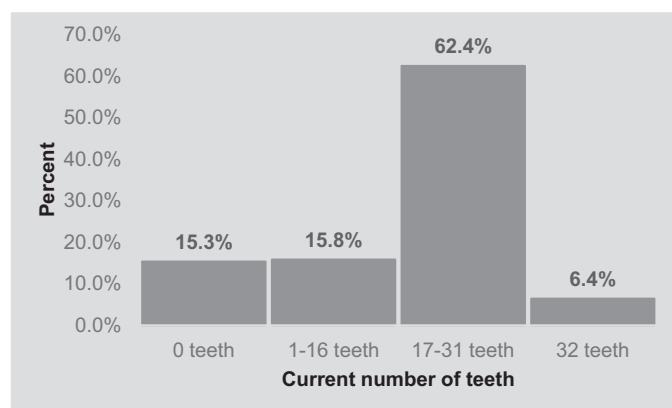

Figure 1. Current number of teeth in survey respondents, n = 202.

Table 2
Dental hygiene practices and dental health status of survey respondents with teeth, n = 171

	Number (%)
Dental hygiene practices	
Brush teeth daily	168 (83.2%)
Floss daily	100 (58.5%)
Use mouthwash daily	114 (67.1%)
Dental health status	
Have had a deep-cleaning	125 (73.1%)
Have loose teeth	14 (8.2%)
Experience tooth sensitivity	52 (30.4%)
Gums bleed	56 (32.9%)
Responses suggestive of periodontal disease (i.e. one or more of above)	150 (87.7%)

Table 3
Results of univariate analyses of survey variables included in model versus number of teeth

Variable	Mean number of teeth (or correlation coefficient r)	p-value
History of or currently smoking*	17.45 for yes, 22.39 for no	0.001
Reports flossing daily*	20.69 for no, 24.96 for yes	0.001
Presence of retinopathy*	16.00 for yes, 20.64 for no	0.023
Presence of neuropathy*	17.20 for yes, 21.88 for no	0.003
Presence of nephropathy*	16.12 for yes, 21.19 for no	0.006
Responses suggestive of periodontal disease*	22.76 for yes, 26.24 for no	0.007
Age, in years*	Correlation coefficient r = –0.304	<0.001
Duration of diabetes, in years*	Correlation coefficient r = –0.140	0.047
Time since last visit to dentist, in months*	Correlation coefficient r = –0.264	<0.001

* Significant at p < 0.05.

diabetes, smoking status, presence of nephropathy, presence of neuropathy, presence of periodontal disease, number of months since last visit to a dentist), age ($\beta = -0.146$; 95% CI: –0.062 to –0.230), not flossing ($\beta = -3.462$; 95% CI: –1.107 to –5.817), and presence of retinopathy ($\beta = -4.271$; 95% CI: –1.307 to –7.236) remained as significant independent predictors of a lower number of remaining teeth in patients with diabetes.

Discussion

Our study results showed a high prevalence of dental loss and periodontal disease among patients with diabetes. When adjusting for smoking status, duration of diabetes, presence of periodontal disease and other complications, and number of months since last dental visit, there were significant associations between increased dental loss and older age, not flossing and the presence of diabetic retinopathy.

The effect of poor glycemic control in causing microvascular disease (retinopathy, neuropathy and nephropathy) and macrovascular disease (heart attacks and stroke) is well established and has resulted in specific recommendations for preventing and managing these complications (foot care, eye exams, monitoring albuminuria, etc.). Conversely, the effect of diabetes on oral health is underappreciated by the medical providers and endocrinologists caring for patients with diabetes [9–12]. Periodontal disease is a major risk factor for dental loss; however, despite being more prevalent and more severe in patients with diabetes, it has not received similar attention compared to the other complications of diabetes [13]. There is an absence of abundant evidence showing the beneficial impact of aggressive dental care on desirable outcomes such as the reduction of vascular complications among patients with diabetes [14,15]. In addition,

there is decreased awareness in patients and their medical providers of good strategies for achieving improvement in their dental health. For example, patients with diabetes are less likely to see a dentist, when compared to those without diabetes [5].

In this study, we assessed the oral health status of a sample of our diabetes patient population. We looked at how their dental health is associated with other common clinical variables that predict diabetes outcomes or are the outcomes themselves. We found a high number of patients with survey responses suggestive of periodontal disease (87.7%) in our DM patient population, which is notably higher than the 46% prevalence of periodontal disease in the general population [16]. There was an equally high prevalence of dental loss (93.6%) among our patient population. Compared to the general population, where the proportion of patients who have lost all their teeth was estimated to be 3.75% [17], we found that 31 (15.3%) of our patients with diabetes had lost all of their teeth. Our findings are concordant with those from other studies that have investigated dental loss in patients with diabetes [3,18–20].

As was expected, age was a strong predictor of dental loss, with increasing dental loss at older ages. This is similar to previous reports [19]. The underlying mechanism for the age-related increase in dental loss, outside of other known risk factors (diabetes, smoking, poor oral hygiene and periodontal disease), likely relates to the loss of alveolar bone with advancing age – similar to that found in osteoporosis [21,22]. Indeed, it has been hypothesized that loss of alveolar bone as a result of osteoporosis provides an environment conducive for increased bacterial bone-resorbing factors with the eventual destruction of periodontal tissue and tooth loss if untreated [22].

Smoking and periodontal disease are known risk factors for dental loss and were significant in the univariate analyses but not significant in the regression model (after adjustment for other variables). It is likely that the effect of these variables was less profound in a diabetes population, similar to the findings of Javed et al., where periodontal inflammatory conditions were comparable among smokers and non-smokers with diabetes but were more severe in smokers without diabetes compared to non-smokers without diabetes [23]. It is also possible that the other variables in the model, such as age and flossing, had a more profound effect on dental loss, thus, limiting the effect of smoking and periodontal disease on dental loss within our sample diabetic population.

We also found that patients with diabetic retinopathy had fewer teeth than those who did not have retinopathy. This is similar to findings reported in a study conducted in Pima Indians that found a higher prevalence of periodontal disease and dental loss in diabetes patients with retinopathy [18]. This relationship may be explained by chronic systemic inflammation [24], which is more common in patients with periodontal disease and those with retinopathy. This inflammatory response to periodontal disease, left untreated, results

Table 4
Results of multiple linear regression of survey variables for prediction of remaining number of teeth

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for β	
	β	Std. error	Beta			Lower bound	Upper bound
(Constant)*	32.064	2.862		12.599	.000	30.411	41.717
Age, in years*	–.146	.043	–.248	–3.427	.001	–.230	–.062
Smoking	–2.017	1.123	–.128	–1.796	.074	–4.235	.200
Last visit to dentist, in months	.005	.014	.029	.399	.691	–.022	.033
Retinopathy*	–4.271	1.501	–.219	–2.845	.005	–7.236	–1.307
Nephropathy	–1.733	1.377	–.097	–1.259	.210	–4.453	0.986
Neuropathy	–.64	1.177	–.004	–.054	.957	–2.389	2.262
Not flossing*	–3.462	1.192	–.217	–2.903	.004	–5.817	–1.107
Responses suggestive of periodontal disease	–2.210	1.688	–.092	–1.309	.192	–5.543	1.123
Duration of diabetes, in years	.081	.060	.106	1.360	.176	–.037	.199

* Significant at p < 0.05.

in dental loss and also may contribute to the initiation of microvascular disease such as retinopathy.

Among all the forms of dental care practices, flossing was the only technique that was significantly associated with reduced dental loss in our population, after adjusting for other dental loss risk factors. This is likely because flossing, which assists in plaque removal, is more effective than brushing and use of mouthwash in reducing inflammation and preventing periodontal disease – a cause of dental loss [25].

Limitations

Given that this was a cross-sectional study, we were only able to show associations between the variables of interest rather than direct causation, but our results can guide the design of observational studies that further explore the degree of causation that these variables may have with regard to dental loss. Also, although we found some significant associations between dental loss and certain clinical variables, a larger sample size may provide greater power to assess the effect of some of the other clinical variables that did not achieve significance in the present study.

Conclusion

Our findings highlight the burden of disease among patients with diabetes as a result of poor dental care. There is a significant and notable association between dental loss and having diabetic retinopathy. Our findings also suggest that good dental care, with particular emphasis on regular dental flossing, may have a significant impact on preventing dental loss in patients with diabetes.

Acknowledgments

Conflict of Interest

The authors declare they have no conflicts of interest.

References

[1] American Diabetes Association. Economic costs of diabetes in the U.S. in 2012. Diabetes Care 2013;36(4):1033–46.

[2] Centers for Disease Control and Prevention. National diabetes statistics report: estimates of diabetes and its burden in the United States, 2014. U.S. Department of Health and Human Services; 2014.

[3] Kapp JM, Austin Boren S, Yun S, LeMaster J. Diabetes and tooth loss in a national sample of dentate adults reporting annual dental visits. Prev Chronic Dis 2007;4(3):A59.

[4] Kanjirath PP, Kim SE, Rohr Inglehart M. Diabetes and oral health: the importance of oral health-related behavior. J Dent Hyg 2011;85(4):264–72.

[5] Tomar SL, Lester A. Dental and other health care visits among U.S. adults with diabetes. Diabetes Care 2000;23(10):1505–10.

[6] Martin JA, Page RC, Loeb CF, Levi PA Jr. Tooth loss in 776 treated periodontal patients. J Periodontol 2010;81(2):244–50.

[7] Takata T, Donath K. The mechanism of pocket formation. A light microscopic study on undecalcified human material. J Periodontol 1988;59(4):215–21.

[8] Izuora K, Ezeanolue E, Schlauch K, Neubauer M, Gewelber C, Umpierrez G. Impact of periodontal disease on outcomes in diabetes. Contemp Clin Trials 2015;41:93–9.

[9] Al-Khabbaz AK, Al-Shammari KF, Al-Saleh NA. Knowledge about the association between periodontal diseases and diabetes mellitus: contrasting dentists and physicians. J Periodontol 2011;82(3):360–6.

[10] Lin H, Zhang H, Yan Y, Liu D, Zhang R, Liu Y, et al. Knowledge, awareness, and behaviors of endocrinologists and dentists for the relationship between diabetes and periodontitis. Diabetes Res Clin Pract 2014;106(3):428–34.

[11] Owens JB, Wilder RS, Southerland JH, Buse JB, Malone RM. North Carolina internists' and endocrinologists' knowledge, opinions, and behaviors regarding periodontal disease and diabetes: need and opportunity for interprofessional education. J Dent Educ 2011;75(3):329–38.

[12] Tasdemir Z, Alkan BA. Knowledge of medical doctors in Turkey about the relationship between periodontal disease and systemic health. Braz Oral Res 2015;29(1):55.

[13] Chavarry NG, Vettore MV, Sansone C, Sheiham A. The relationship between diabetes mellitus and destructive periodontal disease: a meta-analysis. Oral Health Prev Dent 2009;7(2):107–27.

[14] Lockhart PB, Bolger AF, Papapanou PN, Osinbowale O, Trevisan M, Levison ME, et al. Periodontal disease and atherosclerotic vascular disease: does the evidence support an independent association?: a scientific statement from the American Heart Association. Circulation 2012;125(20):2520–44.

[15] Tonetti MS, VanDyke TE. Periodontitis and atherosclerotic cardiovascular disease: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. J Clin Periodontol 2013;40(Suppl. 14):S24–9.

[16] Eke PI, Dye BA, Wei L, Thornton-Evans GO, Genco RJ, CDC Periodontal Disease Surveillance Workgroup. Update on prevalence of periodontitis in adults in the United States: NHANES 2009 to 2012. J Periodontol 2015;86(5):611–22.

[17] National Institute of Dental and Craniofacial Research. Tooth loss in adults (age 20 to 64). NIDCR, 2015.

[18] Loe H. Periodontal disease. The sixth complication of diabetes mellitus. Diabetes Care 1993;16(1):329–34.

[19] Luo H, Pan W, Sloan F, Feinglos M, Wu B. Forty-year trends in tooth loss among American adults with and without diabetes mellitus: an age-period-cohort analysis. Prev Chronic Dis 2015;12:E211.

[20] Patel MH, Kumar JV, Moss ME. Diabetes and tooth loss: an analysis of data from the National Health and Nutrition Examination Survey, 2003–2004. J Am Dent Assoc 2013;144(5):478–85.

[21] Streckfus CF, Parsell DE, Streckfus JE, Pennington W, Johnson RB. Relationship between oral alveolar bone loss and aging among African-American and Caucasian individuals. Gerontology 1999;45(2):110–14.

[22] Wactawski-Wende J. Periodontal diseases and osteoporosis: association and mechanisms. Ann Periodontol 2001;6(1):197–208.

[23] Javed F, Al-Kheraif AA, Salazar-Lazo K, Yanez-Fontenla V, Aldosary KM, Alshehri M, et al. Periodontal inflammatory conditions among smokers and never-smokers with and without type 2 diabetes mellitus. J Periodontol 2015;86(7):839–46.

[24] Hung HC, Willett W, Merchant A, Rosner BA, Ascherio A, Joshipura KJ. Oral health and peripheral arterial disease. Circulation 2003;107(8):1152–7.

[25] Sambunjak D, Nickerson JW, Poklepovic T, Johnson TM, Imai P, Tugwell P, et al. Flossing for the management of periodontal diseases and dental caries in adults. Cochrane Database Syst Rev 2011;(12):CD008829.