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Diabetes-related parameters and periodontal conditions in children

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Background and Objective: The relationship between diabetes and periodontal diseases is well established. Our aim in this study was to explore the diabetes-related parameters that are associated with accelerated periodontal destruction in diabetic youth.

Material and Methods: Three-hundred and fifty 6–18-year-old children with diabetes received a periodontal examination. Data on important diabetes-related variables were collected. Analyses were performed using logistic regression, with gingival/periodontal disease as the dependent variable, for the whole cohort and separately for two subgroups (6–11 and 12–18 years of age).

Results: Regression analyses, adjusting for age, gender, ethnicity, frequency of prior dental visits, dental plaque, and dental examiner, revealed a strong positive association between mean hemoglobin A1c over the 2 years prior to inclusion in the study and periodontitis (odds ratio = 1.31, $p = 0.030$). This association approached significance in the younger subgroup (odds ratio = 1.56, $p = 0.052$, $n = 183$). There was no significant relationship between diabetes duration or body mass index-for-age and measures of gingival/periodontal disease in this cohort.

Conclusion: These findings suggest that accelerated periodontal destruction in young people with diabetes is related to the level of metabolic control. Good metabolic control may be important in addressing periodontal complications in young patients with diabetes, similarly to what is well established for other systemic complications of this disease.

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Diabetes mellitus, a chronic metabolic disorder characterized by hyperglycemia, leads to significant systemic complications and increases morbidity and mortality in affected individuals. A substantial body of literature has demonstrated that diabetes significantly increases the prevalence, severity, and rate of progression of periodontal diseases (reviewed in refs 1,2), and periodontitis is recognized as one of the complications of diabetes (3).

A number of reports on the relationship between diabetes and periodontal disease have included children and adolescents (reviewed in ref. 2). However, these studies were somewhat limited, with respect to the number of subjects assessed and the type of data collected and analyzed. In a cohort of children and adolescents with diabetes (6–18 years of age), we recently reported a significant increase in periodontal diseases compared with that seen in nondiabetic controls (4). The effect of diabetes on periodontal destruction was significant, even when the youngest subjects were analyzed separately. These results demonstrated that diabetes increases the risk for periodontal destruction, even early in life. The aim of the present study was to explore the diabetes-related parameters that might be associated with the observed accelerated periodontal destruction in 350 diabetic children and adolescents from this cohort.

Material and methods

Study population and oral examination

The study protocol was approved by the Columbia University Medical Center Institutional Review Board. Parents/legal guardians of participants signed a consent form. Details about the study population, and recruitment and examination protocols have been described previously (4). Our analyses in the present study focus on 350 children and adolescents with diabetes, 6–18 years of age, who were recruited from among the patients followed at the Naomi Berrie Diabetes Center, Columbia University Medical Center. Participants and/or their guardians responded to questions concerning the participants' dental history. Periodontal assessments were performed on all fully erupted permanent teeth present in one randomly assigned maxillary and the diagonally opposite mandibular quadrant. Levels of dental plaque were assessed using the Plaque Index (5), gingival inflammation was assessed using the Gingival Index (6), and probing depth and location of the gingival margin were recorded and used to compute clinical attachment loss.

Diabetes-related variables

The following information, related to the subjects' diabetes, was collected from medical records.

1 Type of diabetes, duration (years since diagnosis), age at diagnosis.
2 Height and body weight, for calculation of body mass index. In addition, body mass index-for-age and percentile ranks, signifying nutritional status (7), were calculated based on The United States Centers for Disease Control and Prevention age- and gender-specific growth charts (8).
3 Insulin regimen (multiple daily insulin injections or continuous subcutaneous insulin infusion), oral hypoglycemic medications, and any other medications.
4 Laboratory data, including measurements of hemoglobin A1c and lipid profiles.

Data and statistical analysis

Analyses were performed using SAS, version 9.1 (SAS Institute, Cary, NC, USA). First, we computed summary statistics of the demographic, periodontal, and diabetes-related variables in our population, and compared younger and older subgroups (6–11 and 12–18 years of age) using unadjusted Student's *t*- and chi-square tests. Then, we performed formal analyses, using logistic regression, with three definitions of gingival/periodontal disease as the dependent variable, for the whole cohort and separately for the two age subgroups. The first definition combined both attachment loss and gingival bleeding findings: at least two teeth with at least one site having attachment loss > 2 mm and bleeding (i.e. Gingival Index ≥ 2) at the same site. The second definition was based on the presence of gingival bleeding only: at least two teeth with at least one site having bleeding (i.e. Gingival Index ≥ 2). The third definition was based on attachment loss measurements only: at least two teeth with at least one site with attachment loss > 2 mm. Independent variables included: hemoglobin A1c (mean value of all tests performed in the 2 years prior to the dental examination, excluding any tests that were within 3 mo of diagnosis of diabetes), duration of diabetes (square-root transformed to achieve a better fit), and body mass index-for-age percentile. Adjusting variables included age (continuous), gender, ethnicity (Hispanic, non-Hispanic), reported frequency of prior dental visits (log transformed to achieve a better fit), Plaque Index, and dental examiner. A p-value of < 0.05 (two-sided) was considered to be statistically significant for all analyses.

Results

Table 1 describes demographic and periodontal parameters of the study population (all and by age subgroup). Mean age was 11.33 years, 44% were female, and 31% Hispanic. Awareness of gingival bleeding, but not of redness/inflammation, was higher among the parents/guardians of children in the older age group (unadjusted $p = 0.017$). The majority of the sites examined harbored dental plaque in both groups, but gingival bleeding was

Table 1. Demographic and clinical periodontal characteristics of the study population

	All ($n = 350$)	6–11 years ($n = 183$)	12–18 years ($n = 167$)
Age, years	11.33 ± 3.41	8.52 ± 1.72	14.41 ± 1.74
Gender, female	153 (44)	85 (46)	68 (41)
Ethnicity			
Hispanic	109 (31)	52 (28)	57 (34)
Non-Hispanic	241 (69)	131 (72)	110 (66)
Reported frequency of dental visits, per year	1.56 ± 0.74	1.65 ± 0.73	1.45 ± 0.73
Reported age at first dental visit, years	3.97 ± 2.22	3.75 ± 1.89	4.18 ± 2.50
Reported ever had red/inflamed gums	46 (14)	23 (13)	23 (14)
Reported ever had bleeding gums	99 (29)	42 (24)	57 (35)
Mean Plaque Index	1.28 ± 0.36	1.25 ± 0.37	1.31 ± 0.35
Percentage of sites with plaque (PI ≥ 1)	94.23 ± 13.33	92.94 ± 15.33	95.52 ± 10.88
Mean Gingival Index	1.14 ± 0.32	1.10 ± 0.30	1.18 ± 0.33
Percent of bleeding sites (GI ≥ 2)	18.96 ± 21.38	16.54 ± 18.77	21.35 ± 23.51
Mean attachment loss, mm	1.22 ± 1.11	1.01 ± 0.95	1.43 ± 1.21
Number of affected teeth[a]	3.48 ± 4.97	1.66 ± 2.95	5.29 ± 5.85

Data shown as mean ± SD, or *n* (%).
[a]Having at least one site with > 2 mm of attachment loss.
GI, Gingival Index; PI, Plaque Index.

Table 2. Diabetes-related variables in the study population

	All ($n = 350$)	6–11 years ($n = 183$)	12–18 years ($n = 167$)
Diabetes type			
type 1	325 (93)	181 (99)	144 (86)
type 2	25 (7)	2 (1)	23 (14)
Duration, years	3.96 ± 3.39	3.17 ± 2.46	4.83 ± 4.02
Age at diagnosis, years	7.54 ± 4.00	5.43 ± 2.74	9.91 ± 3.88
Treated with			
insulin only	326 (93)	182 (99)	144 (86)
• multiple daily injections	223 (64)	124 (68)	99 (59)
• continuous subcutaneous infusion	103 (29)	58 (32)	45 (27)
oral hypoglycemic medication(s) only	8 (2)	0 (0)	8 (5)
both	11 (3)	0 (0)	11 (7)
Mean HbA1c over past 2 years, %	8.49 ± 1.74	8.11 ± 1.40	8.91 ± 1.97
< 7.5%	97 (29)	59 (33)	38 (23)
7.5–9.5%	170 (50)	96 (54)	74 (45)
> 9.5%	73 (21)	22 (13)	51 (32)
BMI, kg/m^2	21.50 ± 6.43	18.59 ± 3.86	24.70 ± 7.15
BMI-for-age, percentile	70.84 ± 26.20	69.44 ± 26.43	72.39 ± 25.93
BMI-for-age based nutritional status Indicator			
at risk of being overweight (85th to 94th percentile)	74 (21)	48 (26)	27 (16)
overweight (≥ 95th percentile)	69 (20)	22 (12)	47 (28)

Data shown as *n* (%) or mean ± SD.
BMI, body mass index; HbA1c, hemoglobin A1c.

present at significantly more sites in the older age group compared with the younger age group (unadjusted $p = 0.041$). As expected, attachment loss, calculated as either a subject-based mean or as the number of affected teeth having at least one site with > 2 mm of attachment loss, was also significantly higher in the older children (unadjusted $p < 0.001$).

Diabetes-related variables are presented in Table 2. Ninety-three per cent of the children had type 1 diabetes and were treated with insulin only. Fourteen per cent of the children in the 12–18-year-old group had type 2 diabetes. Duration of diabetes was 3.96 ± 3.39 years (median 3.40). Twenty-nine per cent of all children were on continuous subcutaneous insulin infusion (insulin pump). Mean hemoglobin A1c over the 2 years prior to the examination was 8.49 ± 1.74%, and 79% of all children had hemoglobin A1c ≤ 9.5%. Significantly more children in the older age group had hemoglobin A1c > 9.5% (32 vs. 13% in the younger age group, unadjusted $p < 0.001$). Body mass index-for-age percentiles were similar in the two groups, but actual body mass index was significantly higher in the 12–18 years age group (24.70 ± 7.15 kg/m^2) than in the 6–11 years age group (18.59 ± 3.86 kg/m^2; unadjusted $p < 0.001$). Furthermore, a higher percentage of the older children had a poor nutritional status indicator, based on their body mass index-for-age (28 vs. 12% were overweight or above the 95th percentile, unadjusted $p < 0.001$). Finally, total cholesterol and lipid profiles were generally within normal limits and similar in the two age subgroups. Total cholesterol was 169 ± 36 mg/dL, high-density lipoprotein cholesterol was 57 ± 15 mg/dL, low-density lipoprotein cholesterol was 92 ± 29 mg/dL, and triglycerides were 101 ± 63 mg/dL.

As shown in Table 3, using a periodontitis case-definition which incorporates both gingival bleeding and attachment loss findings, formal regression analyses, adjusting for several relevant variables, revealed a strong positive association between mean hemoglobin A1c and periodontitis in this population (odds ratio = 1.31, $p = 0.030$). Our study was not powered for age subgroup analysis; however, this association was positive and approached significance in the 6–11-year-old age group (odds ratio = 1.56, $p = 0.052$, $n = 183$), and did not reach significance in the older subgroup. Hemoglobin A1c was a significant correlate of gingival bleeding (Table 4) in the whole population (odds ratio = 1.23, $p = 0.041$) and the older subgroup (odds ratio = 1.35, $p = 0.030$), but did not reach significance in the younger group. When only attachment loss measurements were considered (Table 5), the only diabetes-related characteristic that showed a statistically significant, but very weak, association with periodontitis was

Table 3. Estimated odds ratios from logistic regression models[a] for having at least two teeth with attachment loss and bleeding[b]

	OR	95% CI	*p*-value
All			
Mean HbA1c	1.31	(1.03, 1.66)	0.030
Duration of diabetes[c]	0.82	(0.50, 1.36)	0.448
BMI-for-age percentile	1.01	(1.00, 1.03)	0.125
Age 6–11 years			
Mean HbA1c	1.56	(1.00, 2.46)	0.052
Duration of diabetes[c]	1.00	(0.40, 2.47)	0.996
BMI-for-age percentile	1.00	(0.97, 1.02)	0.823
Age 12–18 years			
Mean HbA1c	1.33	(0.91, 1.95)	0.146
Duration of diabetes[c]	0.85	(0.40, 1.79)	0.663
BMI-for-age percentile	1.03	(1.00, 1.06)	0.058

[a]Models also adjusted for age, gender, ethnicity, reported frequency of dental visits, plaque index, and dental examiner.
[b]Having at least one site with > 2 mm of attachment loss and bleeding (Gingival Index ≥ 2).
[c]Square root transformation performed to achieve better fit.
BMI, body mass index; HbA1c, hemoglobin A1c.

Table 4. Estimated odds ratios from logistic regression models[a] for having at least two teeth with bleeding[b]

	OR	95% CI	*p*-value
All			
Mean HbA1c	1.23	(1.01, 1.49)	0.041
Duration of diabetes[c]	0.93	(0.65, 1.33)	0.691
BMI-for-age percentile	1.01	(0.99, 1.02)	0.346
Age 6–11 years			
Mean HbA1c	1.04	(0.74, 1.46)	0.827
Duration of diabetes[c]	0.99	(0.57, 1.73)	0.975
BMI-for-age percentile	1.00	(0.99, 1.02)	0.829
Age 12–18 years			
Mean HbA1c	1.35	(1.03, 1.78)	0.030
Duration of diabetes[c]	0.87	(0.51, 1.48)	0.605
BMI-for-age percentile	1.02	(1.00, 1.04)	0.124

[a]Models also adjusted for age, gender, ethnicity, reported frequency of dental visits, plaque index, and dental examiner.
[b]Having at least one site with Gingival Index ≥ 2.
[c]Square root transformation performed to achieve better fit.
BMI, body mass index; HbA1c, hemoglobin A1c.

Table 5. Estimated odds ratios from logistic regression models[a] for having at least two teeth with attachment loss[b]

	OR	95% CI	*p*-value
All			
Mean HbA1c	1.01	(0.81, 1.27)	0.910
Duration of diabetes[c]	0.87	(0.55, 1.37)	0.543
BMI-for-age percentile	1.02	(1.00, 1.04)	0.006
Age 6–11 years			
Mean HbA1c	1.18	(0.77, 1.81)	0.448
Duration of diabetes[c]	0.79	(0.38, 1.59)	0.493
BMI-for-age percentile	1.02	(1.00, 1.04)	0.122
Age 12–18 years			
Mean HbA1c	0.91	(0.65, 1.28)	0.605
Duration of diabetes[c]	1.01	(0.49, 2.08)	0.987
BMI-for-age percentile	1.06	(1.02, 1.11)	0.007

[a]Models also adjusted for age, gender, ethnicity, reported frequency of dental visits, plaque index, and dental examiner.
[b]Having at least one site with > 2 mm of attachment loss.
[c]Square root transformation performed to achieve better fit.
BMI, body mass index; HbA1c, hemoglobin A1c.

body mass index-for-age percentile, again in the whole population (odds ratio = 1.02, $p = 0.006$) and in the older subgroup (odds ratio = 1.06, $p = 0.007$).

Discussion

To the best of our knowledge, this is the largest report, to date, on the periodontal status of children with diabetes. Our recent data (4), comparing children with diabetes to nondiabetic controls, demonstrated that diabetes significantly increases the risk for periodontal destruction earlier than previously identified (9). In studying young individuals, it is important to assess periodontal changes both at the soft tissue level (early, 'acute' inflammatory response to the bacterial challenge) and at the connective tissue attachment/alveolar bone level (cumulative, more advanced 'chronic' response). Using both gingival bleeding and attachment loss measurements, the present study revealed that hemoglobin A1c is a significant correlate of periodontitis. When measures of attachment loss and gingival bleeding were used separately, some interesting findings emerged; hemoglobin A1c was positively and significantly correlated with gingival bleeding, but not with attachment loss alone. These findings suggest that changes in the periodontal microvasculature in young individuals with diabetes are related to the level of metabolic control. Therefore, good glycemic control might be essential in the prevention of periodontal complications in young patients with diabetes, a concept that is in accordance with what is well established for other systemic complications of diabetes (10–12). Exploring the complex pathogenic mechanisms underlying these associations was beyond the scope of this study. However, evidence suggests that mechanisms which account for the development of other diabetic complications might also be operating in the pathogenesis of increased periodontal destruction in diabetes (13,14).

Based on previous evidence, the relationship between specific diabetes parameters and periodontal status is difficult to define conclusively. Most studies have focused on adults and metabolic control, and suggest that the situation for periodontitis is similar to that for the other systemic complications of diabetes; metabolic control appears to be an important variable in the onset and progression of periodontitis, but substantial heterogeneity exists in the diabetic population (2). In regard to its association with periodontitis, diabetes duration has been studied much less, and although conflicting data exist (15–17), a few reports have suggested that longer disease duration might be associated with poorer periodontal health (9,18,19). In our present regression models, we used diabetes duration both as a continuous variable, but also dichotomized as short (< 5 years) or long (≥ 5 years) (data not shown), and in both occasions, its association with periodontal disease did not reach significance.

Our previous findings, in a subset of 182 diabetic children (4), suggested a modest, but statistically significant, association between body mass index and attachment loss. There has also been a suggestion in the literature for an association between obesity and periodontitis in adults (20,21). We therefore included body mass index-

for-age as an independent variable in our models here. Although the attachment loss–body mass index association reached statistical significance, the odds ratios do not indicate any clinical significance.

An oral examination is one of the components of the initial diabetes visit for children and adolescents that is recommended by the American Diabetes Association (22). Taken together, our data suggest that prevention and early identification/treatment of periodontal diseases in young patients with diabetes should be considered as a standard of continuing care visits. Furthermore, increasing evidence suggests that treatment of periodontal infections in adults with diabetes may have a beneficial effect on metabolic control (23,24). This may be especially important in adolescents, who experience poor metabolic control more frequently than adults (11), and in whom optimal control is a major challenge as a result of physiologic changes (pubertal growth and development) and personal behavior (25).

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