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Gender Differences in Periodontal Status and Oral Hygiene of Non-Diabetic and Type 2 Diabetic Patients

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Abstract:**Background:**

This study investigated gender dependent differences by the comparison of periodontal status and oral hygiene between diabetic patients and non-diabetic subjects.

Methods:

517 mostly obese subjects (171 non-diabetic, 205 type 2 diabetic with oral and 141 with insulin therapy; mean: 59 years) completed an oral hygiene questionnaire and had a clinical examination, including periodontal screening and recording (PSR), percentage of bleeding teeth (PBT), probing pocket depth (PD), gingivitis index (GI), and number of teeth (Tn). Main parameters were “periodontitis” and “oral hygiene behaviour”, each defined by 5 sub-parameters. For a comparison of all results, each sub-parameter was set 0.2. The “low performance index“ (LoP) was the sum of significantly worse sub-parameters in the compared groups (maximum of low performing = 1.0).

Results:

Gender comparison: In non-diabetic and diabetic patients with oral medication, males performed worse (LoP: periodontitis 0.6 - 0.8; oral hygiene 0.4 - 0.6). The male insulin group performed worse oral hygiene (LoP: 0.4) than females with insulin therapy, whereas the periodontal status showed no difference.

Diabetic and non-diabetic groups: Females: Diabetic groups performed worse than non-diabetics (LoP: periodontitis 0.2 - 1.0; oral hygiene 0.4). Insulin patients had worse periodontal status and showed no difference in oral hygiene when compared to diabetic patients with oral medication (LoP: 0.2). Males: Diabetic group with oral medication had worse periodontal status than non-diabetics (LoP: 0.6).

Conclusions:

The periodontal status was mainly due to oral hygiene behaviour, which was worse in men. Apparently behaviour and not diabetes is the major determinant of periodontitis. Men apparently need much more advise than women.

Keywords: Diabetes mellitus, Gender, Oral hygiene, Periodontal disease.

INTRODUCTION

Periodontal diseases are bacterial infections of the tissues surrounding and supporting the teeth. Gingivitis, a soft tissue inflammation only, can progress to periodontitis, where the destruction of connective tissue attachment and

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alveolar bone can lead to tooth loss. In most populations the prevalences of severe periodontitis is 10-15 % and diabetes is 6.6 % [WHO]. A greater risk of periodontal disease progression and severity was associated with type 2 diabetes mellitus.

Similarities of periodontitis and diabetes:

- A relatively high incidence in the general population
- Higher incidence with increasing age
- Polygenetic disorders with some degree of immunoregulatory dysfunction that involves an enhanced inflammatory response at the local and systemic level.

Diabetes mellitus is related to changes in bacterial population and the production of inflammatory mediators, and reduces the efficacy of the host response. Patients with periodontitis and diabetes had significantly higher levels of local inflammatory mediators compared to systemically healthy individuals with periodontal disease [1]. Severe periodontal disease causes loss of attachment and alveolar bone and teeth, extending beyond the local level to produce systemic effects, increases local and systemic inflammation. It has a major impact on metabolic control in people with diabetes mellitus [2], increases insulin resistance [3] and potentially worsens cardiovascular disease [4 - 6]. Numerous studies have demonstrated that individuals with diabetes tend to have a higher prevalence and severity of periodontal disease than non-diabetic subjects. An analysis of the Third National Health and Nutrition Examination Survey (NHANES III) data set confirms the significantly higher prevalence of periodontitis in diabetic subjects than in non-diabetics (17 % vs. 9 %) [7]. It was also shown that the prevalence of diabetes in patients with periodontitis is twice as high than the prevalence seen in the non-periodontitis patients (12.5 % vs. 6.3 %). Comparisons of the periodontal health of non-diabetic and type 2 diabetic patients showed that gingival inflammation and attachment loss were elevated significantly in the diabetic patients [8, 9].

The mechanism of diabetes mellitus effect on the course of periodontal pathology is still not clear, but the severity of both diseases was shown to be dependent on various risk factors such as duration and metabolic control of diabetes as well as the age, social behaviour, oral hygiene level and certain aggravating factors (*e.g.* smoking) [10, 11]. Genco *et al.* 2005 [12] evaluated the relationship between obesity, periodontal disease and diabetes mellitus and found a positive relation between BMI and severity of periodontal attachment loss. In the study of Buduneli *et al.* 2014 [13] the BMI was not correlated with clinical periodontal parameters in obese female subjects, but with the serum levels of inflammatory molecules. Increased levels of leptin and interleukin-6 (IL-6) in the obese group might be an explanation for a possible relationship between obesity and periodontal disease [13]. Furthermore it appears possible that periodontitis may stimulate inflammatory change in adipose tissue, creating a triangular self-generating cycle of morbidity linking obesity, diabetes and periodontal disease [14].

Previous studies have shown that better tooth brushing self-efficacy was related to a higher frequency of tooth brushing, less visible plaque and better metabolic control in diabetes [15]. Health behaviour may partly explain the associations between metabolic control in diabetes and periodontal inflammation [16 - 19]. A tendency of higher incidence of periodontal disease was found in males. In the analysis of the NHANES III, the male-to-female prevalence ratios in adults were 1.1 for a probing depth of ≥ 3 mm, 1.4 for a probing depth of ≥ 4 mm, and 1.7 for a probing depth of ≥ 5 mm [20].

In the literature, type 2 diabetes is generally referred to as well/bad controlled, or according to the therapy as NIDDM or insulin dependent. Less information exists on the role of oral antidiabetic (OAD) medication vs. insulin use in relation to periodontitis or oral hygiene behaviour. Glucose control, immune status and severity of diabetes symptoms may largely vary between these groups. Therefore it is a special aspect of the present study to look at the interrelationship between both OAD and insulin therapy in comparison to a non diabetic overweight group.

We further investigated possible gender dependent differences by the comparison of periodontal status and oral hygiene level between non-diabetic and diabetic patients with respect to type of anti-diabetes drugs.

MATERIAL AND METHODOLOGY

Study Population and Clinical Measurements

The data of 517 patients of the Outpatient Ambulance of Sports Medicine at the University of Leipzig were analysed. Measurements of dental health and metabolic state are generally part of the baseline examination in the

ambulance. All relevant clinical characteristics are given in Table 1. Patients were mostly obese and placed in three major groups, separated by gender: non-diabetic subjects (ND: 114 females: aged 37 to 77 years; 57 males: aged 37 to 75 years), diabetic patients with oral medication (OAD: 108 females: aged 35 to 79 years; 97 males: aged 35 to 78 years), and diabetic patients with insulin regimen (INS: 86 females, aged 36 to 79 years, 55 males, aged 38 to 74 years). The body mass index (BMI) was computed by dividing weight in kilograms by the squared height in meters (mean 30.5 ± 5.1 to 34.6 ± 7.4). The control of diabetes was classified by the percentage of glycated hemoglobin in blood (HbA1c). All subjects had a clinical periodontal examination to measure the gingival index (GI), papillary bleeding index (PBI), visible plaque index (VPI), probing pocket depth (PPD), percentage of bleeding teeth (PBT), periodontal screening and recording (PSR), and number of teeth (Tn). Subjects who participated in this study had a minimum of five (mean 19-20) teeth. (Rationale: The number of 5 teeth is a compromise due to a possible statistical interaction between Tn and PPD. On one hand Tn is a relevant clinical parameter of long lasting periodontitis, which is not age dependent in this study since the age does not markedly vary between the groups. On the other hand fewer teeth increase the variance of pocket depth, which is also an "independent" indicator of periodontitis). Diabetes due to pregnancy or pancreatitis was a further exclusion criterion. The clinical dental examination was done by the same examiner dentist to avoid differences in measurements. The depth of the periodontal pockets was measured by probing the sulcus (pocket) of each tooth using a periodontal probe with a coloured strip (running from 3.5 to 5.5 mm) and a 0.5 mm ball at the tip. The probe was inserted into the crevice until resistance was met. Readings were taken at the mesiofacial, midfacial and distofacial areas as well as the corresponding lingual or palatal areas. The highest reading for each sextant was then recorded. Each sextant was rated according to the PSR scale of criteria: PSR code 0: health, code 1: gingivitis, code 2: calculus and gingivitis, code 3: chronic periodontitis with early or moderate attachment loss, code 4: chronic periodontitis with moderate attachment loss or a form of aggressive periodontitis. A PSR code 3 is determined when the coloured band of the probe remains partially visible (pockets = 4-5 mm). A PSR code 4 implies that the coloured band is not visible (pockets ≥ 5.5 mm). The periodontal status was assessed by means of the PSR scoring system. The GI score (Loe and Silness) describes the clinical severity of gingival inflammation. The GI scale criteria are: GI code 0: no bleeding and inflammation, code 1: slight change in colour and mild edema with slight change in texture, mild inflammation, code 2: redness, hypertrophy, edema and glazing, bleeding on probing, moderate inflammation, code 3: marked redness, hypertrophy, edema, ulceration, spontaneous bleeding, severe inflammation.

Questionnaire

Data were collected using a self-completed oral health questionnaire before the clinical examination. Levels of self-care were estimated using indicators of oral health hygiene including frequencies and amount of time used for tooth brushing, approximal cleaning per day, and regularity of dental checkups. Information on smoking habits, and medication use was also obtained using a self-administered questionnaire.

Statistical Analyses

All data are presented as means \pm SD. Analysis of groups across time was done using the Mann-Whitney U test, and independent t-test. A p -value of $p < 0.05$ was considered to indicate significance, and $p < 0.005$ as very significant.

Low Performing Index

For a summarizing comparison of the groups, an additional mathematical attempt was made to show relative differences of the periodontal and oral hygiene status between the various groups.

The main parameters periodontitis and oral hygiene status were each defined by 5 sub-parameters in this study. So, complementary to the clinical data analyses and to sum up the results of the clinical statistics each of the 5 sub-parameters is set as 0.2 (20 %), therefore each main parameter is 1.0 (100 %).

5 Main Parameters of Periodontal Status

PSR = periodontal screening and recording, PBT = percentage of bleeding teeth, PPD5 = number of probing pocket depth of 5 mm, GI = gingival index, Tn = number of teeth.

5 Main Parameters of Oral Hygiene Status

VPI = visible plaque index, TBF = tooth brushing frequency, TBT = tooth brushing time, ICF = interdental cleaning per day, FDC = frequency of dental checkups per year.

So if all sub-parameters (each 0.2) would be worse in one of two compared groups, the relative “low performing index” of this group would be 1. When, e.g., group A is worse in 3 and better in 2 periodontal indices compared with group B, group A has an “low performing index” of 0.2.

RESULTS

Table 1 shows the mean and relative values of biometrics and metabolic control. The study participants were mostly obese. The level of metabolic control, determined by the glycated haemoglobin in the blood, was quite good (HbA1c \leq 7 %) in the patients with oral anti-diabetes drugs and females with insulin therapy. Male diabetic patients with insulin regimen had poorer metabolic control (HbA1c \geq 7 %). Table 2 shows the mean values of periodontal and oral hygiene parameters for all female and male groups.

Table 1. Clinical characteristics of gender separated study participants.

	ND females n= 114	ND males n= 57	OAD females n= 108	OAD males n= 97	INS females n= 86	INS males n= 55
Age	57.32±10.21	59.54±11.03	59.11±10.36	60.12±8.54	59.63±10.39	60.76±8.65
Weight	91.29±21.71	94.53±18.74	91.81±17.33	102.26±18.57	91.55±20.77	103±19.59
Height	1.63±0.53	1.75±0.59	1.64±0.65	1.74±0.62	1.62±0.62	1.76±0.76
BMI	34.27±8.05	30.5±5.08	33.96±5.92	33.76±5.83	34.62±7.35	33.11±5.53
HbA1c			6.55±0.8	6.41±0.8	6.97±0.86	7.15±1.09
Smokers	10 (8.8)	7 (12.3)	3 (2.8)	12 (12.4)	5 (5.8)	5 (9.1)
Antidepressant drugs	20 (17.5)	2 (3.5)	8 (7.4)	2 (2.1)	5 (5.8)	3 (5.5)

Age (yrs), weight (kg), height (m), body mass index (BMI), percentage of glycated hemoglobin in the blood (HbA1c, %), number of smokers (n (%)), and persons who take antidepressant drugs (n (%)) in non-diabetic (ND) and diabetic patients with oral (OAD) or insulin therapy (INS).

Table 2. Description of the study groups according to the periodontal and oral hygiene parameters.

Parameter	ND females n= 114	ND males n= 57	OAD females n= 108	OAD males n= 97	INS females n= 86	INS males n= 55
PSR	1.38±1.37	1.86±1.48	1.67±1.42	2.37±1.42	2.07±1.47	1.92±1.45
PBT	47.98±24.30	56.22±27.36	53.86±28.43	63.28±26.06	61.94±31.05	63.92±28.32
PPD 5mm	4.08±9.55	6.08±8.75	4.33±7.97	8.37±11.63	5.05±7.04	5.87±10.06
GI	1.04±1.03	1.26±1.10	1.30±1.12	1.69±0.94	1.65±1.14	1.47±1.09
Tn	22.3±6.3	22.6±6.5	20.2±6.8	20.3±7.1	19.4±7.4	19.9±7.9
VPI	1.57±0.69	1.99±0.74	1.88±0.76	2.21±0.70	1.95±0.77	2.13±0.82
TBF	1.97±0.49	1.83±0.50	1.91±0.60	1.61±0.72	1.96±0.46	1.73±0.70
TBT	5.89±2.41	4.59±2.08	5.60±2.76	4.72±2.45	5.86±2.90	4.78±2.47
ICF	0.88±0.84	0.67±0.80	0.64±0.81	0.57±0.79	0.60±0.77	0.55±0.81
FDC	1.64±0.57	1.54±0.64	1.61±0.53	1.47±0.58	1.59±0.63	1.45±0.61

Descriptive analysis of periodontal parameters and oral hygiene behaviour after gender dependent categorization: mean periodontal screening and recording (PSR), percentage of bleeding teeth (PBT), number of probing pockets with 5 mm (PPD5), gingival index (GI), number of teeth (Tn), visible plaque index (VPI), tooth brushing frequency per day (TBF), amount of time for tooth brushing per day (TBT), interdental cleaning frequency per day (ICF), and frequency of dental checkups per year (FDC) of the non-diabetes (ND) and diabetes groups with oral (OAD) and insulin therapy (INS).

Female Groups

ND vs. OAD

Female type 2 diabetic patients with oral therapy had a lower number of teeth ($p < 0.02$), more visible plaque ($p < 0.005$), and performed less interdental cleaning ($p < 0.03$) than non-diabetic females (Tables 2 & 3).

ND vs. INS

Compared to non-diabetic women, female type 2 diabetic patients with insulin therapy had less teeth ($p < 0.005$), and more visible plaque ($p < 0.0008$). GI, PSR, the percentage of bleeding teeth and the number of probing pocket depths with 5 mm were all markedly higher ($p < 0.0004$; $p < 0.001$; $p < 0.002$; $p < 0.03$) (Tables 2 & 3).

OAD vs. INS

Compared to diabetic women with oral therapy, female type 2 diabetic patients with insulin therapy had

significantly more mobile teeth ($p < 0.05$), higher HbA1c values ($p < 0.001$) (Table 1), and significant higher GI values ($p < 0.04$) (Table 2 & 3).

Male Groups

ND vs. OAD

Compared to non-diabetic men, male type 2 diabetic patients with oral therapy had a lower number of teeth ($p < 0.02$), higher BMI, GI, and PSR ($p < 0.002$; $p < 0.02$; $p < 0.04$) (Table 1-3).

ND vs. INS

Compared to non-diabetic men, type 2 diabetic males with insulin regimen had a higher BMI ($p < 0.03$) (Table 1).

OAD vs. INS

The HbA1c of 7.15 ± 1.09 % was significantly higher in men with insulin regimen (Table 1).

Table 3. Differences in periodontal parameters and oral health behaviour in non-diabetic and diabetic females/males with oral or insulin therapy. Indicated groups (OAD, INS *e.g.*) had worse parameters.

Table 3. Differences in periodontal parameters and oral health behaviour of all groups after gender subdivision.

Groups	Indices of periodontal status and p-value					Indices of oral hygiene behaviour and p-value				
	PSR	PBT	PPD5	GI	Tn	VPI	TBF	TBT	ICF	FDC
ND vs. OAD Females	•	•	•	•	OAD	OAD	•	•	OAD	•
ND vs. INS Females	INS	INS	INS	INS	INS	INS	•	•	INS	•
OAD vs. INS Females	•	•	•	INS	•	•				
ND vs. OAD Males	OAD	•	•	OAD	OAD	•				
ND vs. INS Males	•					•				
OAD vs. INS Males	•					•				

Abbreviations used: ND = non-diabetic subjects, OAD = diabetic subjects with oral therapy, INS = diabetic subjects with insulin therapy, • = no significant difference, PSR = periodontal screening and recording, PBT = percentage of bleeding teeth, PPD5 = number of probing pocket depth of 5 mm, GI = gingival index, Tn = number of teeth, VPI = visible plaque index, TBF = tooth brushing frequency, TBT = tooth brushing time, ICF = interdental cleaning per day, FDC = frequency of dental checkups per year.

Gender Differences

Non Diabetic Patients (ND)

Non-diabetic males had markedly more probing pocket depths of 5 mm ($p < 0.01$), significantly higher periodontal inflammation scores (PSR ($p < 0.05$) and percentage of bleeding teeth ($p < 0.05$)), markedly more visible plaque ($p < 0.001$), and spent significantly less time for tooth brushing ($p < 0.001$) (Table 4). Their BMI was significantly lower ($p < 0.008$) (Table 4).

Non-insulin Patients (OAD)

Male type 2 diabetic patients with oral therapy showed significantly higher GI ($p < 0.008$) and PSR ($p < 0.0008$), more visible plaque ($p < 0.003$) and spent less time ($p < 0.03$) for less frequent tooth brushing ($p < 0.01$). Male diabetic patients had a significant increase in the number of probing pocket depths of 5 mm ($p < 0.004$), percentage of bleeding teeth ($p < 0.02$) (Table 4).

Insulin Patients (INS)

Gender differences in type 2 diabetic patients with insulin regimen were only found in oral hygiene behaviour. Females brushed their teeth more frequently ($p < 0.05$), and spent more time for brushing ($p < 0.04$) (Table 4).

Table 4. Gender differences in periodontal parameters and oral health behaviour of the non-diabetes group, and diabetes groups with oral or insulin therapy. Only the male or female group with worse periodontal status, oral hygiene is listed.

Table 4. Gender differences in periodontal status and oral hygiene behaviour of all non-diabetic and diabetic subjects.

Group	Indices of periodontal status and p-value					Indices of oral hygiene behaviour and p-value				
	PSR	PBT	PPD5	GI	Tn	VPI	TBF	TBT	ICF	FDC
ND F/M	M	M	M	•	•	M	•	M	•	•
OAD F/M	M	M	M	M	•	M	M	M	•	•
INS F/M	•					•	M	M	•	•

Abbreviations used: ND = non-diabetic subjects, OAD = diabetic patients with oral therapy, INS = diabetic patients with insulin therapy, • = no significant difference, PSR = periodontal screening and recording, PBT = percentage of bleeding teeth, PPD5 = probing pocket depth of 5 mm, GI = gingival index, Tn = number of teeth, VPI = visible plaque index, TBF = tooth brushing frequency, TBT = tooth brushing time, ICF = interdental cleaning per day, FDC = frequency of dental checkups, F = females, M = males.

Low performing index (LoP) within female groups

Periodontal status	ND vs. OAD	OAD 0.2
	ND vs. INS	INS 1.0
	OAD vs. INS	INS 0.2
Oral hygiene	ND vs. OAD	OAD 0.4
	ND vs. INS	INS 0.4
	OAD vs. INS	no difference

The insulin group had the worst periodontal status; hygiene behaviour was worse in both diabetic groups, relative to non-diabetics.

Low performing index (LoP) within male groups

Periodontal status	ND vs. OAD	OAD 0.6
	ND vs. INS	no difference
	OAD vs. INS	no difference
Oral hygiene	no difference between any of the groups	

Low performing index (LoP) female vs. male groups

Periodontal status	ND _{female} vs. ND _{male}	male 0.6
	OAD _{female} vs. OAD _{male}	male 0.8
	INS _{female} vs. INS _{male}	no difference
Oral hygiene	ND _{male} vs. ND _{female}	male 0.4
	OAD _{male} vs. OAD _{female}	male 0.6
	INS _{male} vs. INS _{female}	male 0.4

In summary, male subjects had worse values than women in almost all groups. Only the periodontal status was similar in male or female insulin-dependent subjects.

DISCUSSION

The overall objective of the present investigation was to study gender dependent differences in periodontal status and oral health behaviour of non-diabetic and type 2 diabetic patients with different medication concepts. No such results have come to our knowledge in the literature. A possible relationship between periodontitis, medical management of diabetes and glycemic control was another objective of the study.

Oral Hygiene, Periodontitis and Diabetes in Women

The present results demonstrate less success to maintain oral health in diabetic women, independently of the medication (OAD or insulin), though this difference was limited to the visible plaque index and interdental cleaning (Table 3). Whereas a minor number of teeth were the only difference between non diabetics and OAD, indices of periodontitis were markedly increased in women with insulin regimen in relation to non-diabetics and the gingival

index was significantly higher than in OAD patients (Table 3). Body weight and age in the groups were similar; HbA1c was higher in the insulin group only (Table 1). So a less accentuated care for oral health apparently is a major factor for more severe periodontitis in diabetes. Worse blood glucose management together with higher HbA1c values may further contribute to reduced immune defence and increased low grade inflammation in the insulin group. Other factors, such as age or body weight were similar between the groups and therefore play apparently no major role for the observed differences. Further a cause-effect relationship of increased body weight and periodontitis has not been proven [21, 22], and more studies with longitudinal prospective design are needed. A recent studies reported that increases in BMI were associated with worsening periodontal status in Japanese students [23], whereas another recent study found no correlation between BMI and severity of periodontal disease in non smokers without diabetes mellitus [24].

An explanation for a possible minor interest in oral hygiene cannot be derived from the present results. Depressive mood which may act as a relevant pathogenetic factor for periodontitis [25 - 27] may [28] or may not [29] occur in diabetes. In our study women took more frequently antidepressant medicals than men, especially non-diabetic females (17.5 % vs. 3.5 %), and diabetic women with oral therapy (7.4 % vs. 2.1 %). It cannot be determined if the better oral hygiene was influenced by the antidepressant therapy.

Oral Hygiene, Periodontitis and Diabetes in Men

No significant differences were found in men with respect to oral hygiene behaviour. Only a worse PSR and a minor number of teeth were seen in OAD patients, all other parameters or groups showed no relevant differences (Table 3).

These are interesting results since a worse periodontal status in diabetic patients is generally assumed [30]. This yields, at least in part, for the female group in our present study. In men there was only a minor difference between OAD and non-diabetic male subjects, but not in non-diabetic or OAD vs. insulin dependent patients. Since there was a significant difference in body weight and BMI between non diabetic and diabetic males, it again appears that weight differences alone may not account for a higher risk for periodontitis.

From an absolute point of view oral hygiene and periodontal status were bad in all male groups.

Therefore these facts strengthen the results in women indicating that hygiene behaviour may be the major reason for a better or worse periodontal status, independently of a further systemic disease.

General Gender Differences

Data concerning worse oral hygiene behaviour in males were found in the following studies: Alcouffe 1989 [31] reported in a very small group (26 women, 28 men) a better oral hygiene in women. Strauss and Stefanou 2014 [32] reported in 573 adults with diabetes that females practise more often daily interdental cleaning. A better oral hygiene care among dentate adult women [33], and elderly women [34] were found.

In this present study men performed significantly lower in all groups with respect to oral hygiene and periodontal status with the exception of the insulin therapy group. This is in line with other reports about apparent gender effects on periodontitis.

Desvarieux *et al.* 2004 [35] reported that male subjects between the age of 45 and 75 years and without history of myocardial infarction had nearly 50 % more periodontal disease compared with females. Karikoski *et al.* 2001 [36] assessed the effects of oral self-care on periodontal health indicators among adults with diabetes. Women reported brushing their teeth more frequently, and differences in plaque were significantly lower than those of men.

Merchant *et al.* 2002, 2003 [37, 38] did not find an association between oral hygiene practices and periodontitis in a sample of men in the study cohort. In contrast our present results show a strong correlation between plaque and periodontal parameters, and further indicate that diabetes alone does not necessarily induce higher grades of periodontitis.

Diabetes and Periodontitis- a "Bidirectional" Relationship

Age, smoking, diabetes mellitus and oral hygiene have been consistently linked to periodontal disease [39]. The association of glycaemic disorder with periodontal damage has been investigated in diabetics, and even preclinical glycaemic disorder could be a risk factor for periodontal disease as well [39]. The role of diabetes as causative factor for periodontitis has been proved in a number of studies. Even so, almost half of the relevant papers have not documented such a relationship [40]. The possible relationship between diabetes and periodontitis is often called "bidirectional".

There is evidence that an improvement of acute periodontitis may improve glycemic control rapidly [3]. The effects of chronic improvement of periodontitis on glycemic control are controversially discussed [2, 19, 41], though there is an increasing body of evidence that improved oral health also improves diabetes control [42]. In the present study both lines are found. In the female groups, the underperforming index was markedly higher in diabetes and highest in the insulin group, but these differences were well related to the oral hygiene behaviour. In males there was no relevant relationship between diabetes and periodontitis or diabetes therapy, but there were also no relevant differences between oral hygiene. Males are known for a generally higher incidence of periodontitis (68 %) [43, 44]. Compared with women, non-diabetic and non-insulin males underperformed markedly in the present study.

Altogether, this may indicate on the one hand that oral hygiene behaviour was a major determinant for the periodontal status in our patients and, on the other hand, that diabetes may act more as an intensifying factor than as the primary cause for periodontitis in the present study.

Relation Between Periodontitis and Glycemic Control

According to Bain *et al.* 2009 [45] females with periodontal diseases have a greater risk for inflammatory-based systemic diseases than males. In the present study a comparable periodontal status in men and women was related to similar glycemic control. So this present study does not indicate an apparent greater risk for an increased inflammatory stress in women compared to men.

There was an apparent relation between a worsened periodontal status and the presence of diabetes only in women. But there was also an apparent relation between diligence of oral hygiene and the presence of diabetes. So it remains unclear whether diabetes and periodontal status are cause and effect in the present study. In women with insulin regimen there is a worse periodontal status and glycemic control than in women with oral medication. In contrast, there were no differences in oral hygiene behaviours in these groups. This would support the hypothesis of an interrelationship between glycemic control and periodontal status.

Number of Missing Teeth

The increasing number of missing teeth in diabetics may primarily result from severe periodontitis with tooth mobility or deep pockets. The fact that women had less periodontal inflammation scores but had lost an equal number of teeth might be due to reasons independent of periodontal disease. A number of studies have reported on the relationship between osteoporosis, periodontal disease and tooth loss [46, 47]. So osteoporosis might be another reason for the tooth loss in the postmenopausal women of our study.

Interproximal Cleaning

Tooth brushing may be effective in removing plaque on buccal and lingual surfaces, but it will not reach interdental plaque. A number of other hygiene devices are available to accomplish this: dental floss, interdental brushes, and toothpicks.

Periodontitis and gingivitis lesions are predominantly observed in the interproximal or interdental sites; these sites are most frequently coated with plaque. A toothbrush cannot completely clean the interdental surfaces, so interproximal cleaning represents an important aspect of oral self-care and has beneficial effects on plaque and gingival health [48, 49]. Due to the importance of interproximal cleaning, it is surprising that only few studies exist on this topic. Anyway, our study shows very plainly that the frequency of interproximal cleaning in all groups was far below the recommendations of daily practice and may therefore be a major determinant for increased periodontitis in all groups.

CONCLUSION

The present results show that:

1. Periodontitis was more severe in males than in females, with exception of patients using insulin.
2. Periodontitis was similar in men with or without diabetes. Together with the other results of this study, this may indicate that hygiene behaviour, but not diabetes, is the predominant reason for the periodontal status in our groups.
3. Oral hygiene behaviour appears as the major determinant of oral health in the present study, whereas diabetes apparently had a minor or no effect on periodontal parameters.
4. In the light of these results, oral hygiene behaviour should become a major target in diabetes management.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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