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Radiographic alveolar bone loss in German patients with disabilities and treatment in general anesthesia

Introduction: The cross-sectional study aimed at assessing the periodontal status of German adult patients with disabilities (intellectual, physical, and/or dementia) requiring dental treatment in general anesthesia.

Material and Methods: Between 2011 and 2017, 206 patients received dental treatment(s) in general anesthesia. Periodontal status was retrospectively assessed based on the radiographically visible alveolar bone loss (%). Staging and grading of periodontal disease according to the 2017 classification for periodontal disease was performed. Various general and periodontal parameters, medications, and diagnoses of systemic diseases in association with periodontal diseases were analyzed as potential risk factors for bone loss. Statistical analysis was performed using Pearson correlations, Wilcoxon rank-sum tests, Kruskal-Wallis tests, and multiple linear regressions ($p < 0.05$).

Results: Periapical radiographs were available from 199 patients (86 females; age: 41.1 ± 15.0 years). Based on a distance from the cemento-enamel junction to the marginal bone level exceeding 2 mm, 174 (87.4 %) patients were diagnosed with periodontitis (22.4 ± 20.6 % bone loss). Most periodontitis patients were classified as stage I (39.7 %), followed by stage II (29.1 %), stage III (14.1 %), and stage IV (4.5 %). Generalized periodontitis was most frequently observed in stage I patients ($p \leq 0.047$). Significant predictors of % bone loss were age ($\beta = 0.65$; 95%-CI: 0.40–0.89; $p < 0.001$), intellectual disability ($\beta = 11.87$; 95%-CI: 1.21–22.52; $p = 0.029$), and smoking/nicotine dependence ($\beta = 17.29$; 95%-CI: 3.42–31.16; $p = 0.015$).

Conclusion: Periodontal disease is common in German patients with disabilities. Bone loss is associated with older age, intellectual disability, and smoking/nicotine dependence.

Keywords: alveolar bone loss; patients with disabilities; general anesthesia; radiographic bone loss

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General parameters	– Age – Gender – Type of disability (intellectual, physical, dementia) – Legal guardian (yes, no) – Living situation (care facility, alone, with family) – Nutrition (without restriction, pureed/liquid food, feeding tube) – Oral hygiene (alone, with support, impossible) – Reasons for initial consultation (pain, swelling, caries, prophylaxis, other) – Medications (antihypertensives, anticoagulants, anticonvulsants, sedative drugs, antidepressants, muscle relaxants) – Systemic disorders (diabetes mellitus, obesity, smoking/nicotine dependence) – Immunologic disorders (Down syndrome, HIV infection)
Periodontal parameters	– Tooth loss (excluding wisdom teeth as assessed on radiographs) – Bone loss as a function of age – Presence of subgingival calculus – Radiographic furcation involvement

Table 1 Extracted general and periodontal parameters

1. Introduction

In 2017, about 7.8 million people with severe disabilities lived in Germany. This number is equivalent to 9.4 % of the total population [20]. According to definition of Book IX of the German Social Law Code (§2, SGB IX), the physical function, mental ability, and/or mental health of people with severe disabilities deviate from the age-typical condition for more than 6 months, so that participation in society is permanently impaired. The most common causes included physical disabilities (59.2 %) as well as cerebral disorders, intellectual, and/or mental disabilities (21.4 %) [21].

As patients with disabilities often show a reduced ability to cooperate, dental treatments have frequently to be performed in general anesthesia [10]. A systematic review revealed that patients with disabilities have a poorer oral hygiene leading to a stronger accumulation of plaque. As a consequence, they show a higher prevalence and greater severity of periodontal disease [1].

Regarding the periodontal status of German adult patients with disabilities, only 3 studies with conflicting results have been published. A recent study found a high prevalence of periodontitis as assessed by Periodontal Screening and Recording (PSR) index among adult patients with intellectual disability undergoing dental treatment in general anesthesia. Within the study population, a PSR code 3 or 4, both indicating periodontitis, was present in 92.3 % [9]. A previous study found that 34 % of adults with disabilities presented deep pockets (6 mm or more). According to the Community Periodontal Index of Treatment Needs (CPITN), 83 % of patients required scaling or complex treatment (categories II and III, equivalent to PSR codes 2 to 4) [18]. Besides these, only one further study evaluated the oral health of adults with disabilities attending Special Olympics Germany by visually assessing gingivitis. Gingivitis prevalence amounted to 58.5 % [19]. Based on this data, the current level of evidence regarding the periodontal status among German patients with disabilities is insufficient.

This cross-sectional study therefore aimed at determining the periodontal status of German patients with disabilities requiring dental treatment in general anesthesia by assessing the radiographically visible alveolar bone loss. Furthermore, potential risk factors (e.g. medications and systemic diseases) for bone loss

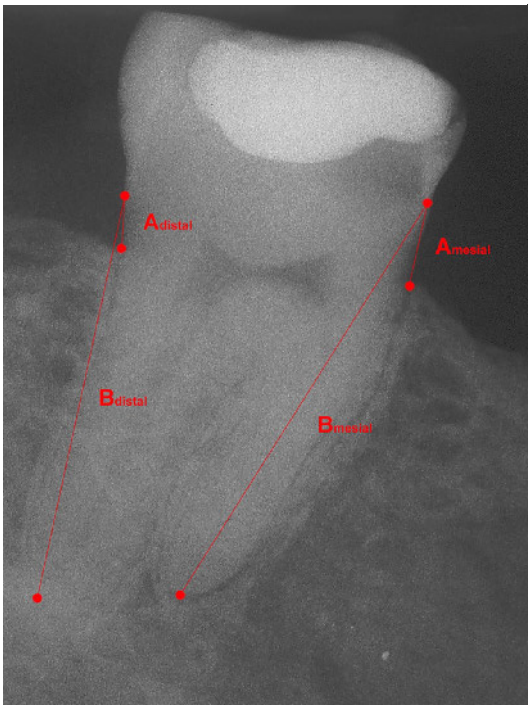

Figure 1 Distance from the cemento-enamel junction to the marginal bone level (*A*). Measurements were taken on the mesial (A_{mesial}) and distal (A_{distal}) sides and averaged arithmetically. Total root length (*B*) as the distance from the cemento-enamel junction to the apex (also measured mesially and distally and averaged arithmetically).

	n	%	p
N	199	100.0	
Age (average years ± SD)	41.1 (15.0)		< **0.001**
BMI (average ± SD, n = 178)	26.0 (7.1)		0.782
Gender			< **0.001**
male	113	56.8	
female	86	43.2	
Type of disability* (n = 194)			
intellectual	170	85.4	< **0.001**
physical	126	63.3	< **0.001**
dementia	14	7.0	< **0.001**
Legal guardian	183	92.0	< **0.001**
Living situation (n = 194)			< **0.001**
care facility	109	56.5	
alone	74	38.3	
with family	10	5.2	
Nutrition (n = 194)			0.189
without restrictions	144	74.2	
pureed/liquid food	31	16.0	
feeding tube	19	9.8	
Oral hygiene (n = 194)			0.248
alone	75	38.7	
with support	93	47.9	
impossible	26	13.4	
Reasons for initial consultation*			
caries (n = 198)	127	63.8	< **0.001**
prophylaxis	73	36.7	< **0.001**
pain	47	23.6	< **0.001**
other	31	15.6	< **0.001**
swelling	16	8.0	< **0.001**

Medication*			
anticonvulsants	88	44.2	< **0.001**
sedative drugs	57	28.6	< **0.001**
antihypertensives	51	25.6	< **0.001**
muscle relaxants	43	21.6	< **0.001**
antidepressants (n = 198)	42	21.2	< **0.001**
anticoagulants	25	12.6	< **0.001**
Systemic/immunologic disorders			
Obesity** (n = 178)	41	23.0	< **0.001**
HIV	0	0.0	-
Diabetes***	13	6.5	< **0.001**
Down syndrome	7	3.5	< **0.001**
Smoking/nicotine dependence**** (n = 198)	10	5.1	< **0.001**

Table 2 Demographic data of all patients and information regarding BMI, type of disability, presence of a legal guardian, living situation, nutrition, oral hygiene, reasons for initial consultation, medication, and systemic/immunologic disorders. p-values indicate univariate effect on % bone loss. In case of missing values, number of included patients are indicated in brackets. Due to the effect of rounding, some numbers do not sum up to 100 %. *Multiple selections were possible. **Defined as body mass index (BMI) ≥ 30 [15]. ***Based on intake of anti-diabetic medication. ****Active smokers or those with less than 5 years since cessation.

were evaluated. Finally, staging and grading of periodontal disease was performed based on the 2017 classification for periodontal disease [16].

2. Material and methods

2.1 Patients

All adult patients with intellectual/physical disability and/or dementia (age ≥ 18 years) who received dental treatment in general anesthesia in the Department of Preventive Dentistry, Periodontology and Cariology between January 2011 and December 2017 were screened (n = 206). Only those patients with full-mouth periapical radiographs were included in the present study (n = 199). The retrospective evaluation study was approved by the local ethics committee of the University Medical Center Göttingen (application number: 15/1/18).

To identify potential risk factors for bone loss, various general and periodontal parameters, medications, and diagnoses of systemic diseases were extracted or calculated from the patient records (see Tab. 1).

Patients' weight and height were extracted from the patient records. Based on these data the body mass index (BMI) was calculated using the following formula:

$$Body\ Mass\ Index = \frac{weight\ [kg]}{height\ [m]^2}$$

A BMI ≥ 30 was defined as obesity [15].

For these parameters and diseases, an association with periodontal diseases has been shown [11].

2.2 Radiographic assessment

The extent of alveolar bone loss was assessed on analogous full-mouth periapical radiographs (Kodak Insight Films IP-21 Size 2; Carestream Health, Rochester, NY, USA). All radiographs were taken by trained dental nurses in parallel technique with the beam angled perpendicular to film. If radiographs were available from multiple time points, the evaluation was based on the latest images. The measurements were performed using a digital caliper (16 ER; Mahr, Göttingen, Germany) to 0.01 mm under 2.5x magnification and standardized conditions. An X-ray image viewer (DSK 15 x 30 ST; Maier, Garmisch-Partenkirchen, Germany) in a darkened room without direct influence of daylight was used.

Except for wisdom teeth and non-restorable retained roots, the distance (*A*) from the cemento-enamel junction or from the restoration margin (if present and exceeding the cemento-enamel junction) to the marginal bone level (most coronal level where the periodontal space still retained its normal width) was measured for each tooth [6]. If the respective tooth was visible on multiple radiographs, the one with best quality was used. Ex-

	Patients without periodontitis		Patients with periodontitis	
	n	%	n	%
N	25	12.6	174	87.4
Tooth loss (excluding wisdom teeth)				
≤ 4 lost teeth	18	72.0	98	56.3
5–8 lost teeth	3	12.0	45	25.9
≥ 9 lost teeth	4	16.0	31	17.8
Radiographic bone loss as a function of age				
< 0.25	25	100.0	52	29.9
0.25–0.5	0	0.0	64	36.8
0.51–1.0	0	0.0	35	20.1
≥ 1.0	0	0.0	23	13.2
Presence of subgingival calculus	5	20.0	120	69.0
Radiographic furcation involvement	0	0.0	52	29.9

Table 3 Measured periodontal parameters among patient with and without periodontitis. Due to the effect of rounding, some numbers do not sum up to 100 %.

tremely distorted images were excluded from the analysis. If possible, all teeth were measured at their mesial and distal sides and the final bone level calculated as the arithmetical average [3, 6, 12, 17]. In case of overlaps with adjacent structures resulting in unassessable measurement sites, only one site per tooth was assessed.

$$A_{tooth} = \frac{A_{mesial} + A_{distal}}{2}$$

At tooth level (A_{tooth}) a value of up to 2 mm was considered physiological (no bone loss), while a value above 2 mm was defined as periodontitis [14]. At patient level, the highest value A_{tooth} was decisive for the classification of periodontal disease.

Furthermore, the total root length (B) was calculated as the distance from the cemento-enamel junction or from the restoration margin (if present and exceeding the cemento-enamel junction) to the apex or apices of the mesial and distal roots. These measurements were performed mesially and distally and averaged (Fig. 1).

$$B_{tooth} = \frac{B_{mesial} + B_{distal}}{2}$$

If A_{tooth} exceeded 2 mm, the % bone loss was calculated for each tooth from the ratio of A_{tooth} and B_{tooth}.

$$Radiographic\ bone\ loss = \frac{A_{tooth} - 2\ mm}{B_{tooth} - 2\ mm}$$

In patients with periodontal disease, classification of periodontitis severity was based on the % radiographic bone loss and divided into different stages: stage I (< 15 %), stage II (15–33 %), and stage III (> 33 %). The presence of further complexity factors (vertical bone loss ≥ 3 mm and/or radiographically visible furcation involvement) also led to the classification in stage III. Cases of stage III were classified as stage IV if only fewer than 20 remaining teeth were present. In addition, information regarding the extent was added to the stage as a descriptor: periodontitis was either present as localized (< 30 % of teeth affected) or generalized manifestation [16].

Periodontitis grading was assessed by indirect evidence of progression based on the % radiographic bone loss as a function of age at the most affected tooth. Further risk factors (i.e. smoking status and diabetes) were extracted from the patient files and served as grade modifiers. Grading was divided into 3 grades: grade A (bone loss/age < 0.25, nonsmoker, and no diabetes), grade B (bone loss/age 0.25–1 or smoker < 10 cigarettes per day or diabetes), and grade C (bone loss/age > 1 or smoker with ≥ 10 cigarettes per day) [16]. As no information regarding the level of hyperglycemia (e.g. HbA1c

values) were available, no differentiation between grade B and C based on the diabetic status were made.

Furthermore, the presence of radiographically visible sub-gingival calculus was recorded.

All radiographs were assessed by one calibrated dentist (PK). A random sample (n = 20) was evaluated by another dentist (VH). The main examiner re-assessed the same random sample after several weeks. Both the inter-rater and intra-rater reliability were calculated for the assessment of periodontitis stage, periodontitis grade, presence of subgingival calculus, and radiographic furcation involvement.

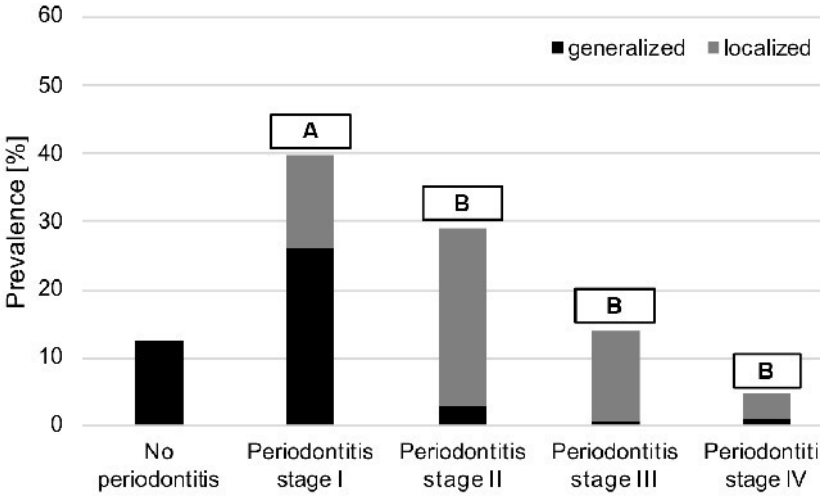

Figure 2 Prevalence and staging of periodontal disease. Different bold letters mark significant different distribution of extent (generalized vs. localized) between stages.

2.3 Statistical analysis

The statistical analysis was performed using the software R (version 3.5.2, www.r-project.org) with the package "irr" (version 0.84).

The extent of periodontal disease was compared between different stages using pairwise Wilcoxon rank-sum tests and adjusted according to Bonferroni-Holm.

As part of the univariate analysis, the correlation of patients' age and BMI (continuous variables) with % bone loss was analyzed by Pearson correlations. The influence of dichotomous variables, such as gender (male/female), legal guardianship (yes/no), intellectual disability (yes/no), physical disability (yes/no), dementia (yes/no), initial consultation due to pain (yes/no), initial consultation due to swelling (yes/no), initial consultation due to caries (yes/no), initial consultation for prophylaxis (yes/no), other reason for initial consultation (yes/no), intake of medications (i.e. antihypertensives, anticoagulants, anticonvulsants, sedative drugs, antidepressants, and muscle relaxants) and presence of systemic/immunologic disorders (obesity, diabetes, Down syndrome, smoking/nicotine dependence) on % bone loss was assessed using Wilcoxon rank-sum tests. The effect of multi-categorical variables, such as living situation (care facility, alone or with family), nutrition (without restrictions, pureed/liquid food or feeding tube), and oral hygiene status (alone, with support or impossible) on % bone loss was assessed using Kruskal-Wallis tests.

Subsequently, variables being significantly associated ($p < 0.05$) with % bone loss were used in a multiple linear regression model for the prediction of % bone loss.

Inter-rater and intra-rater reliability of the radiographic assessment were evaluated by Cohen's κ (dichotomous variables: presence of subgingival calculus and furcation involvement) and Kendall's W corrected for ties (ordinal variables: periodontitis stage and grade).

For all analyses, the level of significance was set to $p < 0.05$.

3. Results

199 patients were included in this study. Demographic data and information on BMI, type of disability, presence of a legal guardian, living situation, nutrition, oral hygiene, reasons for initial consultation, medication, and systemic diseases of all patients are shown in Table 2.

Periodontitis ($A_{tooth} > 2$ mm) was present in 174 patients (87.4 %). Among these patients, bone loss amounted to 22.4 ± 20.6 %. Further periodontal parameters such as tooth loss, % bone loss as a function of age, and radiographic presence of subgingival calculus and furcation involvement are shown in Table 3 for patients with and without periodontitis.

Among patients with periodontitis, distribution of stages and extent is shown in Figure 2. The extent (generalized vs. localized) of periodontal disease differed significantly between different stages. Generalized periodontitis was more frequent in less severe cases (stage I), while localized periodontitis was predominant in more severe stages ($p \leq 0.047$). Progression of periodontitis was rated as grade B in most patients (n = 123, 70.7 %), followed by grade A (n = 48, 27.6 %), and grade C (n = 3, 1.7 %).

3.1 Univariate analyses

Bone loss was significantly influenced by age ($p < 0.001$) and increased in older patients ($r = 0.38$). Smoking (+12.5 %), Down syndrome (+11.5 %), anticoagulants (+10.2 %), the existence of a legal guardian (+8.3 %), antihypertensives (+6.9 %), intellectual disability (+5.8 %), psychological disability (+5.4 %), living in a care facility (+4.0 %), consultation due to prophylaxis (+4.4 %), physical disability (+1.9 %), anticonvulsants (+1.8 %), antidepressants (+1.8 %), sedative drugs (+0.9 %), female gender (+0.8 %), consultation due to pain (+0.7 %), obesity (+0.4 %), and consultation due to other reasons than caries, pain, prophylaxis, or swelling (+0.02 %) were significantly related to increased % bone loss ($p < 0.001$). While consultation due to swelling (-8.7 %), living alone (-7.2 %) or with family (-4.1 %), muscle relaxants (-3.2 %), diabetes (-1.1 %), and consultation

due to caries (-0.1 %) were significantly related to decreased % bone loss ($p < 0.001$).

BMI, nutrition, and oral hygiene status had no significant effect on bone loss.

3.2 Multiple linear regression model

Significant variables from the previous univariate analysis were included in a multiple linear regression model for the prediction of % bone loss (Tab. 4). The model was significant at $p < 0.001$ with an adjusted R^2 of 0.19 and a Cohen's f^2 of 0.48 which can be regarded as large effect size [7]. When adjusted for the other variables in the model (gender, kind of disability, presence of a legal guardian, living situation, reasons for initial consultation, medications, obesity, diabetes, and Down syndrome), age ($\beta = 0.65$; 95%-CI: 0.40–0.89; $p < 0.001$), intellectual disability ($\beta = 11.87$; 95%-CI: 1.21–22.52; $p = 0.029$), and smoking/nicotine dependence ($\beta = 17.29$; 95%-CI: 3.42–31.16; $p = 0.015$) remained as significant independent predictors of % bone loss in patients with disabilities.

Intra-rater reliability was almost perfect [13] (Cohen's κ: 0.90 presence of sub-gingival calculus, 1.0 furcation involvement; Kendall's W: 0.91 periodontitis stage, 0.93 periodontitis grade). Inter-rater reliability of the radiographic assessment was mostly substantial [13] (Cohen's κ: 0.69 presence of sub-gingival calculus, 0.60 furcation involvement; Kendall's W: 0.80 periodontitis stage, 0.76 periodontitis grade).

4. Discussion

There is strong evidence that patients with intellectual disease show a greater prevalence and severity of periodontal disease than the general population [1]. These studies focused on patients with mental retardation (e.g. Down syndrome) and developmental disability (e.g. autism). While many studies are available from all over the world, information about the situation in Germany is rare.

In the present study among German patients with disabilities, periodontal disease was present in the majority of patients (n = 174, 87.4 %). Among these, bone loss amounted to 22.4 ± 20.6 %. Patients' age, intellectual disability, and smoking/nicotine dependence were significant independent predictors of increased % bone loss in the present population of patients with disabilities. Further factors, such as patients' gender, presence of a legal guardian, living situation, reasons for initial consultation, medications, obesity, diabetes, and Down syndrome were not significantly related to bone loss in the multiple linear regression model.

As limitation of the present study, the very heterogeneous group of patients (different kinds of/reasons for and extent of disabilities) must be noted. Patients with intellectual disabilities, physical disability, and/or dementia were included. This heterogeneity might lead to differences in patients' lifestyles and a large variation regarding the degree of autonomy. Furthermore, the course of life of patients with later-onset dementia is likely to be very different from those patients with inborn intellectual disabilities affecting their ability to perform oral hygiene measures. As a consequence, disabilities' impact on the oral hygiene status is likely to vary among the included patients. For example, patients with intellectual disabilities have difficulties to perform an acceptable oral hygiene from childhood on while patients with dementia usually have had a long phase in their life where they could perform oral hygiene in an acceptable way.

Due to missing periodontal measurements (e.g. clinical attachment loss, Periodontal Screening and Recording [PSR] index, and inflammatory activity), periodontal status was assessed on radiographs only. As most of the assessed radiographs were taken during general anesthesia where perfect parallel technique with the beam angled perpendicular to film was not always possible, minor inaccuracies are likely to have impacted on the meassurements. In addition, overlaps with adjacent structures (e.g. *Proc. zygomaticus*, wisdom teeth) or endotracheal tube resulted in sometimes unassessable measurement sites which were omitted. To address these issues, measurements were performed twice and averaged (mesially and distally), and bone loss was expressed as percentage of root length rather than absolute values.

Both age and smoking/nicotine dependence have been shown to be related to bone loss in the literature [11, 16]. Regarding further patient-related factors, results of the present study are partly in contrast to the existing knowledge as some of them have previously been shown to be significantly associated with periodontal disease [11]. This difference might be explained by the population of the present study: the number of patients bearing certain risk factors (e.g. Down syndrome or diabetes) was relatively small. As the assessment of diabetes was only based on the intake of anti-diabetic medications, undetected diabetes within the non-diabetic group cannot be ruled out. Within the group of already treated diabetes patients, the diabetic status (i.e. level of hyperglycemia) was not available. Therefore, results regarding the effect of diabetes have to be interpreted with caution [11]. Except for the radiographic bone and tooth loss, data on all variables were only self-reported by the patients, caregivers, and/or their legal guardians. This might have added further inaccuracy.

A direct comparison regarding the prevalence of periodontitis in patients with disabilities with the prevalence among patients without disabilities based on data derived from other studies is difficult due to inconsistent definitions of periodontitis. Even among studies which assess periodontal status radiographically, different treshholds are used. In the present study, a value of up to 2 mm was considered physiological (no bone loss), while a value above 2 mm was defined as periodontitis. This threshold is derived from the 2017 definition of periodontal health [14]. Even when adjusting this treshold to < 3 mm as used in previous studies [2, 4, 5], periodontitis was present in n = 132 patients (66.3 %). Based on this treshold, periodontitis based on radiographic assessment was more often present in patients with disabil-

	β	95% confidence interval for β		Std. error	t	Sig.
		Lower bound	Upper bound			
(Intercept)	-18.61	-41.32	4.10	11.49	-1.62	0.108
Age	0.65	0.40	0.89	0.13	5.17	**< 0.001**
Gender	-0.91	-6.87	5.06	3.02	-0.30	0.756
Intellectual disability	11.87	1.21	22.52	5.39	2.20	**0.029**
Physical disability	-1.98	-8.75	4.80	3.43	-0.58	0.566
Dementia	-9.77	-22.52	2.99	6.46	-1.51	0.133
Legal guardian	5.07	-7.86	18.00	6.54	0.77	0.440
Living situation	-2.00	-7.38	3.39	2.72	-0.73	0.465
Initial consultation due to caries	-0.85	-7.34	5.65	3.29	-0.26	0.797
Initial consultation due to prophylaxis	4.30	-1.97	10.57	3.18	1.36	0.177
Initial consultation due to pain	1.25	-5.77	8.28	3.56	0.35	0.725
Initial consultation due to swelling	-2.13	-12.46	8.21	5.23	-0.41	0.685
Initial consultation due to other reasons	2.70	-5.70	11.09	4.25	0.63	0.527
Antihypertensives	4.26	-3.42	11.94	3.89	1.10	0.275
Anticoagulants	5.64	-3.05	14.32	4.39	1.28	0.202
Anticonvulsants	2.23	-3.97	8.43	3.14	0.71	0.478
Sedative drugs	-6.45	-13.45	0.56	3.55	-1.82	0.071
Antidepressants	-0.93	-8.63	6.77	3.90	-0.24	0.811
Muscle relaxants	-4.74	-12.32	2.84	3.84	-1.24	0.219
Obesity*	-0.43	-7.66	6.80	3.66	-0.12	0.907
Diabetes**	-6.09	-17.91	5.73	5.98	-1.02	0.310
Down syndrome	6.23	-10.00	22.46	8.21	0.76	0.450
Smoking/nicotine dependence***	17.29	3.42	31.16	7.02	2.46	**0.015**

Table 4 Results of multiple linear regression analysis for prediction of % radiographic alveolar bone loss. *Defined as body mass index (BMI) ≥ 30 [15]. **Based on intake of anti-diabetic medication. ***Active smokers or those with less than 5 years since cessation.

ities, than in adults without disabilities with a reported prevalence between 17.9 % [4] and 26.0 % [5].

Regarding the prevalence of periodontitis in German patients with disabilities, only 2 studies of patients with disabilities have been published [9, 18]. In a small population (n = 52), periodontitis (PSR code 3 or 4) was present in 92.3 % [9]. However, the high prevalence of periodontitis might be related to the assessment tool (PSR index). Even initial periodontitis or gingiva hyperplasia caused by other reasons than peri-

odontitis (e.g. drug intake) might have been reported as periodontal disease [8]. As opposed to the PSR index, radiographs only allow for the evaluation of true bone loss as a consequence of periodontitis.

Another study among German adults with disabilities found a prevalence of 83 % based on CPITN (categories II and III) [18]. However, the same limitations as with the PSR index apply. Furthermore, a direct comparison between results assessed by PSR index and treatment need according to CPITN is not possible. As CPITN category II is equivalent to both PSR code 2 and 3, studies based on CPITN (categories II and III) are likely to show a higher prevalence of periodontitis than those based on PSR (code 3 + 4).

A third study reports on the periodontal status among German athletes with disabilities [19]. However, the authors visually assessed gingivitis rather than periodontitis; gingivitis prevalence amounted to 58.5 %. As gingivitis usually precedes periodontitis, prevalence of periodontitis can be expected to be less or maximal up to this value. Because mean age of athletes (30.8 years) was lower than the average age of patients included in the present study, a lower prevalence of periodontitis might be explained by age-related differences. Furthermore, athletes might favor a different lifestyle, be better cared for, and live more autonomously than average patients with disabilities in Germany.

Dental professionals, patients' caregivers, and legal guardians should be aware of periodontal disease among patients with disabilities. For the prevention of periodontal disease, dental hygiene instructions tailored for caregivers are necessary in order to improve dental hygiene performance among patients' caregivers. Since 2018, both patients and their caregivers are entitled to these measures according to Book V of the German Social Law Code (§22a, SGB V). German dentists should treat patients with disabilities and their caregivers according to these requirements.

5. Conclusion

Periodontal disease is common in German patients with disabilities. Older age, intellectual disability, and smoking/nicotine dependence are associated with increased bone loss.

Conflicts of interest:

The authors declare that there is no conflict of interest within the meaning of the guidelines of the International Committee of Medical Journal Editors.

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