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Psychological risk indicators for peri-implantitis: A cross-sectional study

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Abstract

Aim: The aim of this analytical cross-sectional study was to evaluate the association between peri-implantitis and psychological distress, and potentially related/mediating factors such as general health, bruxism, and lifestyle factors.

Materials and Methods: Patients who received dental implants at a private practice in the Netherlands between January 2011 and January 2014 were recalled on a 5-year clinical and radiographic follow-up examination. Presence of peri-implantitis was examined, and patients completed questionnaires measuring psychological distress (Symptom Checklist [SCL]-90), bruxism, general health, and lifestyle factors. Associations between the self-reported factors and peri-implantitis were analysed with univariate and multivariate logistic regression models.

Results: A total of 230 patients (with 347 implants) were included in the analysis. Prevalence of (mild to severe) peri-implantitis was 30% (69 patients). Variables that showed a significant univariable association with peri-implantitis ($p < .10$) were the SCL-90 subdomain depression, smoking, current medical treatment, and lung problems. In the multivariate regression analysis, depression was the only variable that was significantly associated with peri-implantitis ($p < .05$).

Conclusions: The presence of depressive symptoms is a risk indicator for peri-implantitis. Recognizing the potential negative impact of depressive symptoms may allow for better identification of high-risk patients.

KEYWORDS

bruxism, dental implants, peri-implantitis, psychological distress, risk factors

Clinical Relevance

Scientific rationale for study: Positive association between psychological distress and periodontitis has been established, but this is unclear for peri-implantitis.

Principal findings: Peri-implantitis is more prevalent among patients with depressive symptoms than among patients without depressive symptoms.

Practical implications: The level of psychological distress and, more specifically, depressive symptoms should be taken into account when attempting to identify patients at high risk for developing peri-implantitis. Additional preventive and therapeutic measures, such as postponement of

implant placement, shortening of peri-implant/periodontal maintenance intervals, and, if not yet diagnosed, referral for further psychodiagnostics and psychological interventions should be considered.

1 | INTRODUCTION

Peri-implantitis is defined as a pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant connective tissue and progressive loss of the supporting bone (Berglundh et al., 2018; Schwarz et al., 2018). It is a serious condition that may eventually lead to implant loss. The onset of peri-implantitis may occur early during follow-up, and the disease progresses in a non-linear and accelerating pattern. Peri-implantitis usually progresses asymptomatically and is therefore often detected only during recall appointments (Klinge et al., 2005).

Weighted mean prevalence of peri-implantitis is estimated to be approximately 10% at the implant level and 20% at the subject level (Derks & Tomasi, 2015; Lee et al., 2017). Peri-implantitis and implant failures tend to cluster in subsets of individuals, and patients who have lost one implant are at elevated risk for future implant losses (Renvert & Quirynen, 2015). This clustering suggests that subject-specific characteristics play an important role in the development of peri-implantitis.

Indeed, an increased risk of developing peri-implantitis is observed in patients with a history of periodontitis, poor plaque control skills, and no regular maintenance care after implant therapy (Schwarz et al., 2018). Other factors (site- or subject-specific) that have been linked to peri-implantitis are smoking, diabetes, lack of keratinized mucosa, post-restorative presence of submucosal cement, and implant malpositioning. However, evidence on these factors is scarce and/or inconclusive (Schwarz et al., 2018). In addition, not much is known about the influence of psychological factors. Chronic psychological stress and depression are known to play a role in periodontitis by dysregulating the immune system, and thereby aggravating periodontal destruction (Warren et al., 2014; Decker et al., 2020, 2021). Stress may also serve as a risk factor for infectious diseases such as periodontitis, through changes in healthy behaviour (poor oral hygiene, smoking, unhealthy diet) (Warren et al., 2014). Although positive associations between depressive symptoms and periodontitis have been described in several studies (Liu et al., 2018; Nascimento et al., 2019), this remains unclear for peri-implantitis. Since periodontitis and peri-implantitis share common characteristics, it is conceivable that the above-mentioned risk factors for periodontitis may be identical for peri-implantitis (Heitz-Mayfield & Lang, 2010).

Another common phenomenon related to mental health problems is insufficient quality of sleep (in a bidirectional way) (Kahn et al., 2013). Sleep continuity as well as the depth of sleep is compromised in a wide variety of mental disorders (Baglioni et al., 2016). This might be especially relevant in peri-implantitis, since psychological stress is associated with impaired sleep and bruxism (van Selms et al., 2013). Implant overloading due to bruxism may serve as a mediating factor between psychological problems and peri-implantitis (Canullo et al., 2015; Dalago et al., 2017), and a correlation between implant failure rates and bruxism has been hypothesized (Chrcanovic et al., 2016). However, there is currently no overall evidence that bruxism and/or occlusal overload constitute risk factors/indicators for the onset or progression of peri-implantitis (Schwarz et al., 2018).

Although it is conceivable that psychological factors, directly or through mediating factors, may be correlated with peri-implantitis, this has rarely been investigated yet. Therefore, the aim of the present cross-sectional study was to evaluate the association between peri-implantitis and psychological distress and potentially related/mediating factors such as general health factors, bruxism, and lifestyle factors.

2 | MATERIALS AND METHODS

2.1 | Study design

The present study is a cross-sectional cohort study, evaluating the association between peri-implantitis and psychological factors, in patients with implants in function for 5 years. The "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) guidelines for reporting a cross-sectional study were followed (von Elm et al., 2014).

2.2 | Participants

Patients who had received dental implants at "Zijlweg Dental", a private practice for implantology in Haarlem, the Netherlands, between January 2011 and January 2014 were asked to participate in the study. Patients had received one or multiple Straumann® bone- or tissue-level implants with sandblasted, large-grit, acid-etched surface (Institut Straumann AG, Basel, Switzerland). All patients reported to be non-smokers at the time of implant placement and had no active periodontal disease (bleeding < 20%, no periodontal pockets > 5 mm). Patients presenting with inadequate oral hygiene, bleeding ≥ 20%, and/or with pockets 4/5 mm during the pre-implantology screening were first referred to and treated by an oral hygienist. Subsequently, implants were placed only if plaque and bleeding levels were good (<20%) and remained stable over a period of at least 2–3 months. Implants were placed in healed extraction sites (at least 3 months of healing) with good primary stability (at least 35 N/cm). Twice-daily 0.12% chlorhexidine + 0.05% cetylpyridinium chloride mouthrinses (Perio-aid, Dentaid SL, Cerdanyola, Spain) were recommended from 2 days before surgery until the sutures were removed after 10 days. Implants were all placed by one experienced implantologist (Hans Strooker).

After an osseointegration period of at least 3 months, patients were referred back to their general dentists for suprastructure placement and regular follow-up and periodontal maintenance (at least twice a year).

Five years after implant placement, all patients were recalled for a follow-up examination. Patients were excluded from the study if they had cognitive impairment, insufficient Dutch language skills, and/or no basic computer skills. Written informed consent was obtained from all patients before inclusion.

2.3 | Variables

During the 5-year follow-up examination, peri-implant health was examined by peri-implant pocket probing with a pressure-sensitive probe (probe force of 0.25 N, Kerr Hawe ClickProbe, Bioggio, Switzerland). Probing pocket depth was scored to the nearest millimetre at four sites per implant. Up to 30 s after probing, the presence or absence of bleeding and suppuration was assessed. All clinical assessments were performed by one and the same examiner (Hans Strooker) with many years of experience in implant dentistry. Digital intra-oral radiographs were obtained with a sensor (XIOSPlus, Dentsply Sirona, Charlotte, NC) using an aiming device and the long-cone paralleling technique. The distance from the shoulder of the implant to the first visible bone-to-implant contact was measured at the mesial and distal side using computer software (Sidexis 4, Dentsply Sirona). Measurements were calibrated using the known dimensions of the implant as reference values. To determine the amount of bone loss over time, radiographs from the follow-up examination were compared with those taken immediately after implant placement. For calculation of inter-observer agreement, radiographic images of 25 randomly selected implants were examined by two researchers/implantologists. Pearson correlation coefficient was .978 both at the mesial and the distal side ($p < .001$, mean of absolute difference = 0.195 mm ± 0.186). Subsequently, Hans Strooker performed all other radiographic measurements.

Peri-implantitis was defined as progressive radiographic bone loss ≥2 mm, combined with the presence of at least one bleeding pocket (bleeding index ≥ 2) of ≥4 mm and/or suppuration.

After the clinical and radiographic examination, patients received an e-mail containing a link to the digital questionnaire. To prevent response bias, patients were kept ignorant about the results of the clinical and radiographical assessment until 2 weeks later (to allow patients to complete the questionnaire first). The questionnaire contained the following items:

- Age (continuous variable), gender (dichotomous variable), education level (ordinal: low, medium, high);
- General health questionnaire (Abraham-Inpijn et al., 2008), including alcohol consumption (number of alcoholic drinks per week, categorized as no consumption, mild/moderate consumption [1–7 drinks/week], or heavy consumption [>7 drinks/week]), smoking and drug abuse (both dichotomous variables [yes/no]);
- Symptom Checklist-90 (SCL-90), a 90-item self-reported symptom inventory measuring general psychological distress (total score) and specific symptoms of distress (subdomains: anxiety, agoraphobia, depression, somatization, cognitive-performance deficits, interpersonal sensitivity, hostility, and sleep difficulties) (Derogatis et al., 1973; Dutch version: Arrindell and Ettema (1981, 2003)). It is one of the most frequently used tests in Europe and the Netherlands for screening on psychopathology and has high reliability and validity (Evers et al., 2012; Egberink et al., 2022). Responses are provided on a 5-point scale (0 = not at all, 4 = very strongly). Out of the six norm groups available for interpretation of the SCL-90 scores (Arrindell & Ettema, 2003), for the present study the "general population" norm group was chosen. The scores for the specific items were classified as being below, at, or above average of the general population norm group (dichotomous variables);
- Bruxism assessment questionnaire (Winocur et al., 2011), measuring self-reported sleep and awake bruxism (bruxism = one or more questions answered with yes; no bruxism = no questions answered with yes; dichotomous variable).

2.4 | Sample size

Sample size for this analytical cross-sectional study was based on a multivariate logistic regression model with an assumed number of six relevant independent variables. Given the requirement of at least 10 events per variable to ensure the validity of a logistic model (Peduzzi et al., 1996), at least 60 patients with peri-implantitis were to be included. Based on an estimated prevalence rate of 22% for peri-implantitis (Derks & Tomasi, 2015) (ranging from initial to severe peri-implantitis), the aim was to include at least 273 patients.

2.5 | Statistical methods

The reliability of bone loss measurements was established by a random sampling of 25 X-rays and having them scored by both the researcher and a second independent implantologist. This distance was scored at the mesial and distal side using computer software (Sidexis 4, Dentsply Sirona). The Pearson correlation coefficient was .978, both at the mesial as the distal side ($p < .001$). The reliability of the SCL-90 questionnaire in the present study population was assessed by calculating Cronbach's alpha.

The linearity of the associations of continuous variables with the outcome was examined by dividing the data into quartiles. Variables that did not show a linear relationship were dichotomized or categorized, depending on the observed data structure.

For pre-selection of potential relevant predictive variables (demographic, general health, psychological distress, and bruxism variables), univariate logistic (logit) regression analyses were performed for all variables separately with the dependent variable (peri-implantitis vs. no peri-implantitis). Variables with less than five observations in both the peri-implantitis group and the non-peri-implantitis group

TABLE 1 Implant-level characteristics

	No peri-implantitis	Peri-implantitis
Patients, *n* (%)	161 (70.0)	69 (30.0)
Implants, total (*n*)	227	81
Implants with peri-implantitis, *n*	0	78
Maxilla/mandibula, %	41.5/58.5	57.0/43.0
Anterior/posterior, %	36.6/63.4	36.7/63.3
Bone-level/tissue-level implant, %	15.0/85.0	22.2/77.8
Prosthetic reconstruction; % implants		
Single crown	70.9	81.5
Fixed partial denture	1.8	2.5
Overdenture, splinted	24.7	14.8
Overdenture, non-splinted	2.6	1.2
Marginal bone loss, mean (SD) (in millimetre)	0.69 (0.43)	2.34 (0.53)
Percentage of implants with bone loss (in millimetre)		
0–1	75.0	0
1–2	23.9	4.5
2–3	1.1	83.6
3–4	0	10.4
>4	0	1.5

were not taken into account. Variables with a significant association ($p < .10$) were selected for multivariate regression analysis. Collinearity was assessed by checking the correlation coefficients and variance inflation factors (VIF). From the highly correlated variables (correlation coefficient > .70 or VIF > 3), only the variable with the strongest univariate association with the dependent variable was included in the multivariate logistic (logit) regression model. Data were analysed using SPSS® (version 23.0.0.3, IMB, Armonk, NY).

3 | RESULTS

The total cohort of 541 patients, implanted between January 2011 and January 2014, were invited to participate in the study. In total, 240 patients accepted the invitation and were clinically and radiographically examined. Ten patients did not complete the questionnaire, leaving a total of 230 patients (with 308 implants in total) for inclusion in the analysis (response rate 43%). Prevalence of (mild to severe) peri-implantitis at the patient level was 30% (69 patients) and at the implant level 25.3% (78 implants).

A reliability analysis was carried out on the construct of general psychological distress (total SCL-90 score), comprising the eight subdomains. Cronbach's alpha showed the SCL-90 to reach good reliability in the present study population ($\alpha = .872$). Most subdomains resulted in a decrease in the alpha if deleted. The one exception was the subdomain "sleep difficulties", which would slightly increase alpha to .896.

Implant-level characteristics are shown in Table 1. Descriptive statistics and the results from the univariable and multivariable analysis are shown in Table 2. The four variables that showed a significant univariate association with peri-implantitis ($p < .10$) and thus were included in the multivariate model were the following: the SCL-90 subdomain depression, smoking (yes vs. no), current medical treatment ("Are you currently in treatment by a doctor or medical specialist?"), and lung problems ("Do you have lung problems, like asthma, bronchitis, or chronic cough?"). In the multivariable regression analysis, only the variable "depression" was significantly associated with peri-implantitis ($p < .05$).

The percentages of peri-implantitis and non-peri-implantitis patients with above averages scores on the SCL-90 subdomains are shown in Figure 1.

4 | DISCUSSION

The present study aimed to evaluate the association between peri-implantitis and psychological distress, general health factors, bruxism, and lifestyle factors. Significantly more patients with peri-implantitis scored above average on depressive symptoms than patients without peri-implantitis. In addition, there was a trend (although not significant) of above average scores on all the investigated psychological variables, being higher in the peri-implantitis group (except the hostility subdomain). Especially, the (borderline significant) higher score on anxiety symptoms is noticeable.

Previous studies in patients with psychiatric diagnoses have shown associations between several anxiety- and depression-related psychiatric conditions and tooth decay, greater tooth loss, and bleeding gums. However, the findings vary widely between different studies regarding the relationship between psychiatric problems and periodontitis (Kisely et al., 2016). Although the population in the present study consisted of patients from an implant dentistry practice instead of psychiatric patients, the observed associations are in line with the substantial body of evidence indicating that psychological stress, chronic stress-related diseases such as depression, and inadequate coping can influence the onset and progression of many chronic inflammatory diseases, including periodontitis (Genco et al., 1999; Warren et al., 2014; Decker et al., 2020, 2021). Chronic stress may result in the suppression of both the cellular and innate immune response, leading to increased susceptibility to infection, delayed wound healing, and increased periodontal tissue destruction (Decker et al., 2021). In addition, chronic stress can mediate the risk and progression of periodontitis through changes in health-related behaviours, such as oral hygiene, smoking, and diet, and/or indirectly through chronic stress-related co-morbidities such as diabetes and obesity (Warren et al., 2014). Mechanisms underlying the association between chronic stress and periodontitis might be similar for peri-implantitis, but more research is necessary to substantiate this hypothesis.

In general, the SCL-90 is considered a reliable tool for measuring general psychological distress (total score) and specific symptoms of

TABLE 2 Descriptive statistics and univariable and multivariable associations with peri-implantitis

Variable	No peri-implantitis $n = 161$	Peri-implantitis $n = 69$	Univariable analysis			Multivariable analysis		
			OR	95% CI	*p*	OR	95% CI	*p*
Age (years), mean (SD)	64.4 (11.3)	62.9 (10.8)	0.992	0.969–1.016	.518			
Gender; M (male), F (female)	M 61, F 100	M 32, F 37	0.705	0.399–1.248	.230			
Education level; patients, *n* (%)								
Low[a]	23 (17.4)	8 (15.1)						
Medium	36 (27.3)	14 (26.4)	1.118	0.406–3.082	.829			
High	73 (55.3)	31 (58.5)	1.221	0.493–3.026	.666			
Unknown	29	16						
Periodontal status; patients, *n* (%)								
Currently healthy[a]	137 (85.1)	62 (89.9)						
Current (mild) periodontitis	2 (1.2)	1 (1.4)	1.659	0.641–4.296	.297			
Fully edentulous	22 (13.7)	6 (8.7)	1.833	0.141–23.824	.643			
SCL-90; patients, *n* > average score (%), [mean (SD)]								
Total score	37 (23.0) [111.1 (24.6)]	22 (31.9) [118.2 (30.6)]	1.569	0.839–2.932	.158			
Anxiety	21 (13.0) [11.7 (3.0)]	15 (21.7) [12.6 (3.6)]	1.852	0.890–3.855	.100			
Agoraphobia	18 (11.2) [7.6 (1.6)]	9 (13.0) [7.7 (1.9)]	1.192	0.507–2.802	.688			
Depression	32 (19.9) [20.2 (5.9)]	24 (34.8) [22.4 (7.7)]	2.150	1.147–4.032	.017*	2.036	1.067–3.884	.031*
Somatization	24 (14.9) [15.1 (3.8)]	14 (18.8) [15.7 (4.6)]	1.325	0.630–2.786	.458			
Cognitive-performance deficits	36 (22.4) [12.2 (3.6)]	19 (27.5) [12.8 (4.3)]	1.319	0.692–2.516	.400			
Interpersonal sensitivity	24 (14.9) [21.9 (5.8)]	15 (21.7) [23.3 (6.8)]	1.586	0.773–3.251	.208			
Hostility	19 (11.8) [6.8 (1.4)]	8 (11.6) [7.1 (1.9)]	0.980	0.407–2.360	.964			
Sleep difficulties	52 (32.3) [4.9 (2.3)]	26 (37.7) [5.6 (2.8)]	1.267	0.704–2.283	.430			
Bruxism; patients *n* with score ≥ 1 (%)	59 (36.6)	31 (44.9)	1.410	0.796–2.500	.239			
Smoking; patients, *n* (%)	12 (7.5)	11 (15.9)	2.355	0.984–5.635	.054*	2.245	0.910–5.541	.079
Alcohol consumption; patients, *n* (%)								
No[a]	38 (23.6)	18 (26.1)						
Mild/moderate (1–7 drinks/week)	69 (42.9)	20 (29.0)	0.612	0.289–1.295	.199			
Heavy (>7 drinks/week)	54 (33.5)	31 (44.9)	1.212	0.594–2.475	.598			
Medical questionnaire; patients, *n* (%) (significant results only)								
Current medical treatment	42 (26.1)	27 (39.1)	1.821	1.002–3.312	.049*	1.468	0.780–2.765	.234
Lung problems	7 (4.3)	8 (11.6)	2.885	1.003–8.301	.049*	2.380	0.781–7.246	.127

Abbreviations: CI, confidence interval; OR, odds ratio; SCL, Symptom Checklist.
[a]Reference category.
*Statistically significant ($p < .10$ for univariable analysis, $p < .05$ for multivariable analysis).

distress, with good (criterion and construct) validity (Egberink et al., 2022). Specifically, the subdomains "anxiety" and "depression" have shown good convergent and divergent validity (Koeter, 1992). Unfortunately, the SCL-90 has not been used frequently in periodontal research, yet. One study, using the depression and somatization subscales of the SCL-90 only, found higher scores in patients with higher levels of gingival bleeding, suggesting that somatization and depression might play a role in gingival inflammation (Klages et al., 2005). A limitation of the present study is the fact that the SCL-90 scores were dichotomized into "above average" and "below/at average". This was done because the SCL-90 scores were not normally distributed. However, this inevitably results in less refined

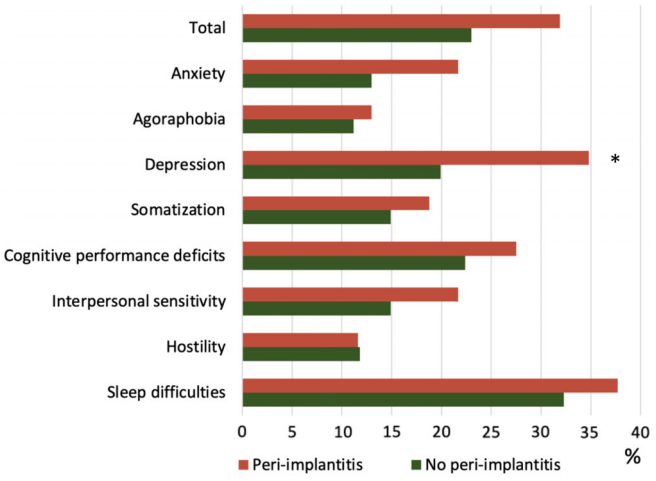

FIGURE 1 Percentages of patients with above average Symptom Checklist-90 scores

outcomes. Although the dichotomization was not arbitrary, but based on the grades of the SCL-90 norm group scores, the groups may have had a broader range of psychological distress than if a more refined division were used to describe the severity of psychological distress. The results should therefore be interpreted with caution.

It has been suggested that antidepressants can interfere with bone metabolism and as such may increase the risk of implant failure. A recent systematic review and meta-analysis found a risk ratio of 3.73 (95% confidence interval 1.85–7.52, $p = .0002$) for implant failure in antidepressant users compared to non-users (Silva et al., 2021). However, no evidence is available on a potential relationship between use of antidepressants and peri-implantitis, and the number of antidepressant users in the present study was too low in both groups to be taken in into account in the analysis.

In the present study, significantly more peri-implantitis patients than non-peri-implantitis patients reported smoking, having lung problems, and receiving medical treatment. Although the smoking and lung problems seem to be related, the medical care consisted of a variety of treatments, not exclusively related to lung problems. Smoking is a well-known risk factor for periodontitis, as well as for general health problems (Leite et al., 2018; WHO, 2021). The current study supports the findings of an earlier meta-analysis that smoking has potential negative effects on healing and outcome of implant treatment (Chrcanovic et al., 2016) and may add to the risk of peri-implantitis (Devlin & Fee, 2021).

Another factor that is generally considered a major risk factor/indicator for peri-implantitis is a history of chronic periodontitis. There is strong evidence that patients with a history of chronic periodontitis are at higher risk for developing peri-implantitis (Schwarz et al., 2018). In the present study, however, there was no association between periodontal status (currently healthy, current periodontitis, and edentulous) and presence of peri-implantitis. This could be due to the fact that the study population was in general periodontally very healthy. The pre-implantology screening was very strict with regard to periodontal health and oral hygiene requirements, resulting in low prevalence of periodontitis at the 5-years follow-up.

The differences in alcohol use were not significant, but the observed trend was similar to that found in the study of Carr et al. (2021), suggesting that mild to moderate alcohol consumption is associated with lower rates of peri-implantitis and that heavy alcohol consumption is associated with a higher rate of peri-implantitis.

Despite the higher score on depressive symptoms and the trend of higher psychological distress in general in peri-implantitis patients, the percentage of patients with bruxism in both groups did not differ significantly. The same was true for symptoms that indicate sleep disturbances. Although it is generally recognized that bruxism, either sleep or awake, can be an important source of implant overload, the evidence on possible associations between bruxism and implant failures is scarce and inconclusive (Thymi et al., 2021). In addition, and in line with the present study, there is currently no evidence suggesting that bruxism and/or occlusal overload constitute risk factors/indicators for the onset or progression of peri-implantitis (Schwarz et al., 2018). It should be kept in mind, however, that most studies, including the present one, rely on self-reported bruxism instead of using objective methods to diagnose bruxism.

In this sample, the patient-level prevalence of peri-implantitis after 5 years of implant function time was 30%, which is high compared to what is generally found in the literature (Derks & Tomasi, 2015; Lee et al., 2017). This high percentage could be explained by the fact that the chosen threshold for case definition of peri-implantitis was rather low. As a consequence, the peri-implantitis cases ranged from mild/incipient to severe, without making a distinction between them. Since it is known that early bone loss is a predictor for progressive bone loss, development of severe peri-implantitis, and increased risk of implant failure (Galindo-Moreno et al., 2015; Windael et al., 2021), the used threshold allowed for early identification of patients at risk for future problems and identification of associated patient-related factors.

Unfortunately, potential confounding factors such as levels of self-performed infection control and compliance to maintenance recommendations throughout the 5-year follow-up period have not been recorded in the present study. Although all patients were periodontally healthy at the moment of implant placement, had good oral hygiene levels, and were regularly seen for follow-up and periodontal maintenance by the referring dentists and oral hygienists, it is possible that these factors could have influenced the association between peri-implantitis and depression. Other limitations of the present study are the relatively small sample size and the cross-sectional nature of the study. The total sample size was 230 patients, which is lower than the a priori calculated required sample size of 273 patients, but due to the relatively high prevalence of peri-implantitis, the number of patients with the "event" peri-implantitis was still sufficient to uphold the conclusions of this study. However, with a response rate of 43%, it cannot be ruled out that some degree of selection bias (i.e., non-response bias) has occurred, favouring the selection of certain patient characteristics. In addition, due to the cross-sectional nature of the study, it is not possible to make causal inferences on the established

association between psychological distress and peri-implantitis or to distinguish between different durations and intensities of distress. In future research, ideally, a longitudinal study design would be recommended to investigate the development of peri-implantitis in relation to various subject-specific (including psychological) risk factors.

5 | CONCLUSION

Within the limitations of this study, it can be concluded that the presence of depressive symptoms is a risk indicator for peri-implantitis. Recognizing the potential negative impact of depressive symptoms may allow for better identification of high-risk patients and could provide additional options for prevention and therapy of peri-implantitis, such as postponement of implant placement, shortening of peri-implant/periodontal maintenance intervals, and, if not yet diagnosed, referral for further psychodiagnostics and psychological interventions.

AUTHOR CONTRIBUTIONS

The study design was set up by Miriam Margot Bildt. Data collection, project administration and data curation was done by Hans Strooker. Formal analysis was performed by Miriam Margot Bildt and Yvonne Catharina Maria de Waal. The original draft was written by Yvonne Catharina Maria de Waal; Hans Strooker and Miriam Margot Bildt critically reviewed and edited the manuscript. All the authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL STATEMENT

The study was approved by the medical ethics committee of the University Medical Center Groningen, Groningen, The Netherlands (METc M14.154962). The study was conducted between January 2016 and January 2019.

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