Original Research Article

Relationship between peri-implant clinical parameters and increased probing depth in dental implants: a cohort study

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ABSTRACT

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| **Background:** Peri-implantitis has been defined as an inflammatory lesion of the mucosa surrounding an endosseous implant and with progressive loss of supporting peri-implant bone. The peri-implant health consists of the absence of visual signs of inflammation and the absence of bleeding and/or suppuration after gentle probing, with no increase in the probing depth in comparison to prior exams.  **Aims:** The gradual increase in probing depth makes it more difficult to keep the subgingival region healthy, patients should be instructed on how to clean the areas rehabilitated with dental implants, and most professionals still have doubts about the diagnosis and treatment of peri-implantitis.  **Methodology:** This Cohort study carried out at Department of Dentistry University Santo Amaro, São paulo, Brazil, between June 2019 and July 2021. Initially, 208 patients who underwent oral rehabilitation with implants between 2011 and 2012. After defining the eligibility criteria, 73 patients with one unitary external hexagon implant in function for 10 years were included in the study. Participants underwent complete peri-implant examination and were evaluated: probing depth, plaque index, bleeding index and suppuration. Periapical radiographs were taken to verify the current bone level.  **Results:** Peri-implantitis was diagnosed in 37 implants (50.7%) and 36 (49.3%) were healthy. The 37 implants diagnosed with peri-implantitis were influenced by the plaque index and the interaction between probing depth and suppuration (P < .001). The bone loss for implants diagnosed with peri-implantitis, the average was 4.0 mm (P < .001). For plaque index, the average was 3.6 mm (P < .001) and the average for suppuration as 4.0 mm. The implant was diagnosed with peri-implantitis, and the presence of biofilm has affected the PD.  **Conclusion:** Within the limitations of this cohort study, increased plaque index and suppuration were significantly associated with peri-implantitis. Prospective studies with baseline measurements should be performed to elucidate the role of biofilm in peri-implantitis. Biofilm control is essential for the preservation of peri-implant tissues and, depending on the microorganisms involved, host response and other factors such as smoking, diabetes, and inadequate hygiene, we may have the development of disease. |

*Keywords:* *Dental Implants, Single-Tooth, Peri-implantitis, Risk factors, Periodontal index*

1. INTRODUCTION

The high predictability and acceptance of implant therapy have led to a significant increase in the use of dental implants for prosthetic oral rehabilitation (Ríos-Osorio et al., 2024). The number of rehabilitations carried out with dental implants grows exponentially; thousands of implants were installed. Simultaneously, it is expected an increase in the biological complications resulting from the growing number of dental implants and their rehabilitations [1]. There are several studies discussing the prevalence of peri-implant diseases, with various types of methodological definitions, and literature has reported an average prevalence of peri-implantitis of 22%, varying from 1% to 47% [2].

Peri-implantitis has been defined as an inflammatory lesion of the mucosa surrounding an endosseous implant and with progressive loss of supporting peri-implant bone. The peri-implant health consists of the absence of visual signs of inflammation and the absence of bleeding and/or suppuration after gentle probing, with no increase in the probing depth in comparison to prior exams [3, 4, 5]. Peri-implantitis displays progressive bone loss and may compromise the longevity of dental implants while increasing the susceptibility to systemic disorders. Despite shared features related to the etiology and risk factors associated with these disorders, there are notable differences concerning the pathogenesis and pattern of progression, among others. Peri-implant mucositis is diagnosed when the inflammation is confined within the soft tissues (Monje & Salvi, 2024). The correct diagnostic is key to defining the measures to control the peri-implant disease. In the absence of prior exams, the following criteria can be used: presence of bleeding and/or suppuration after gentle probing, probing depth equal to or higher than 6 mm, bone level of 3 mm or more, apical to the most coronal part of the intraosseous portion of the implant. Thus, the development of peri-implantitis is related to an inefficient plaque control, due to the difficult access to the site for hygiene and maintenance, the position of the implant and the presence of keratinized tissue. The plaque index has a dominant role in the prevalence of peri-implantitis, as well as bleeding on probing [6, 7].

Patients must be assessed at regular intervals to monitor their peri-implantitis status, as well as the condition of the prostheses supported by the implant and the control of biofilm. The principles of maintenance must include the regular assessment of the implants and their surrounding prostheses and tissues; occlusal exam; review and reinforcement of the oral hygiene; removal of plaque; treatment or diseases or repair in the prostheses, as needed; and definition of personalized preventive measures [8]. Regular routine and frequent maintenance appointments to motivate patients to professionally control the biofilm may prevent the start or increase of a gingival inflammation in dental implants with mucous membrane-supported prosthesis [9].

The gradual increase in probing depth makes it more difficult to keep the subgingival region healthy, patients are not properly instructed about cleaning sites rehabilitated with dental implants, and most professionals still have doubts about the diagnosis and treatment of peri-implantitis.   
Monitoring the status of dental implants over long periods is important. Relating conditions, habits, and characteristics after years of use can help elucidate some situations, such as the appearance of peri-implant disease, marginal bone loss, and constant local inflammation. The objective of the present study was to evaluate the peri-implant clinical condition of implants installed 10 years ago, associating the probing depth found with the clinical status, the presence or absence of disease and the performance of maintenance consultations over these years.

2. material and methods

**2.1 Study design**

This study is in accordance with Resolution no. 196, of October 16th, 1996, by the National Health Council of Brazil, and the Odontology Professional Ethics Code (Resolution CFO No. 042/2003). All recruited individuals received a verbal and a written explanation of the objectives, methodology, benefits and eventual risks related to the participation in the project. Therefore, the individuals who accepted to participate in the study have signed the Free and Informed Consent Term, previously assessed and approved by the Research Ethics Committee for research with humans of the Universidade Santo Amaro no. 7611/2012.This is a longitudinal, prospective cohort study which has the main objective of clinically and radiographically analyzing dental implants installed 10 years ago. Its secondary objective is to relate the plaque index, bleeding on probing, probing depth, bone loss and annual maintenance with the health/disease status of the implants.

**2.3 Definition of disease**

For this study, the incidence of peri-implant disease has been calculated using the consensus of the 2017 World Workshop for Classifying Periodontal and Peri-Implant Diseases and Conditions. Peri-implantitis is defined in 2017 as a pathological condition associated with plaque which occurs on the tissues around dental implants; it is characterised by an inflammation in the peri-implant mucous membrane and subsequent progressive loss of the supporting bone. Areas with peri-implantitis present clinical signs of inflammation, bleeding on probing and/or suppuration, increase in probing depth and/or recession in the mucous membrane margin, as well as radiographical bone loss. Data from previous exams were not available, therefore the diagnosis of peri-implantitis was based on the combination of: bleeding and/or suppuration on gentle probing; probing depths ≥ 6 mm; bone levels ≥ 3 mm apical of the most coronal portion of the intraosseous part of the implant [10, 11].

**2.4 Eligibility criteria**

This study included individuals of both genders, from 40 to 60 years old, with a unitary external hexagon implant, and surface treated with acid, with screw-retained and the presence of teeth adjacent to the implant.

Individuals who had implants diagnosed with peri-implant mucositis, had more than one implant or smokers were excluded from the study, as well as those individuals who, for any reason, had to suspend the use of systemic medication for clinical evaluation, and individuals in need of antibiotic prophylaxis for carrying out the clinical examinations.

Patients were assessed for annual maintenance and its relationship with peri-implant disease. A regular annual visit to each patient's personal dentist was accepted as maintenance. The patients included in the study had implants installed at the same time and returned after 10 years for this evaluation. Patients who reported not going to the dentist every year were assessed as not having annual maintenance.

**2.5 Clinical data**

Participants underwent complete peri-implant examination and all implants were evaluated: probing depth, plaque index, bleeding index and suppuration presence. All crowns were unscrewed and peri-implant probing was performed. Probing depth (PD) was measured in millimeters with the help of a periodontal probe (Millenium/Golgram, São Paulo, Brazil) from the edge of the mucosa to the bottom of the sulcus, and measurements were taken manually at four different points in all presented implants (buccal, mesial, lingual and distal). Plaque index and bleeding on probing index measurements were performed on 4 sides same as PD and the presence or absence of biofilm and bleeding on probing were evaluated based on a binomial standard, being 0 = absence of plaque and 1 = presence of visible plaque. The clinical exam comprised: probing depth (PD) - 6 points per implant; plaque and bleeding index - 4 dichotomous points [12].

Each clinical parameter has been obtained by two blinded examiner previously calibrated. As a means of assessing inter- and intra-examiner agreement, PD measurements were performed and repeated at one-week intervals in 12 randomly selected individuals from the initial sample group. The data were submitted to the non-parametric Kappa test for intra-examiner agreement of the measurements. A dichotomous criterion at the cutoff point of PS ≥ 4 mm was used to establish the presence or absence of periodontal alteration. The results showed satisfactory weighted Kappa values ​​for PS and NCI of 0.83 and 0.82, respectively (α = .05).

**2.6 Radiographic data**

For all participants, full periapical radiographic exams were carried out, with 14 x-rays in order to verify the height of the bone cortex and support the periodontal diagnosis. The periapical technique applied was the parallelism with the use of a holder to obtain the most isometric image possible. After digitalizing all x-rays, the bone loss was measured on both sides of the implant (mesial and distal sides) by a previously calibrated probe with the support of an image analysis software (version 3.7.0 Digimizer, Medical Software Brolkstraat, Belgium). To correct dimensional distortions in the x-ray, the software was calibrated with the real diameter and length of the implant. Due to the absence of previous exams, the periapical exam served to aid in the diagnosis and was carried out with this objective.

**2.7 Statistical analysis**

The R software was used for analysis. The observed means were compared using Student's t-test. To assess the relationship between the study variables and the disease variable, we used the Wilcoxon test because the variables presented data without normal distribution. In order to compare patients with different characteristics regarding the odds of having the disease, we calculated the Odd Ratio, which is the result of dividing the odds of a patience in a certain category of a categorical variable to have the disease by the odds of a patience in the reference category. Besides Odd Ratio, we showed the Trust Interval of 95% and the p-value of Fisher’s Exact Test, which tests if the Odd Ratio is statistically different from one.

3. results

Initially, 208 patients were selected. Out of them, 62 patients were excluded from the study because they were diagnosed with peri-implant mucositis, 32 patients were excluded with rehabilitation of fixed prosthodontics, 10 patients did not show up to the scheduled exams, 7 patients needed pre-medication for the clinical exams and 24 patients were smokers. The samples were analyzed to assess the behavior of the implants related to the peri-implant disease, more specifically, peri-implantitis, bone loss and probing depth.

A total of 73 single-implant and screw-retained or cemented crowns were assessed. The average age of the patients was 36.1, with the minimum being 29 and the maximum being 56. The frequency of the variable gender in the sample was 45 (61.6%) men and 28 (38.4%) women. Peri-implantitis was diagnosed in 37 implants (50.7%) and 36 (49.3%) of the implants were healthy.

Initially, the main effects of the independent variables, as well as the interactions between them, were evaluated. and thus it was verified that gender, position of the implant and bleeding on probing did not influence whether the implant presented or not the disease. The 37 implants diagnosed with peri-implantitis were influenced by the plaque index and the interaction between probing depth and suppuration (P < .001). Going to the dentist for maintenance appointments or not attending showed no statistical difference in terms of having peri-implantitis (Table 1).

Table 1: Variables analyzed according to health status and peri-implantitis (p≤0,05)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Healthy (%) | Peri-implantitis (%) | Total | p value |
| Male | 24 (66.7%) | 21 (56.8%) | 45 (61.6%) | (P = .47) |
| Female | 12 (33.3%) | 16 (43.2%) | 28 (38.4%) |  |
| Age | 35.9 | 36.2 |  | (P = .71) |
| Position |  |  |  |  |
| Superior | 14 (38.9%) | 14 (37.8%) | 28 (38.4%) | (P = 1) |
| Inferior | 22 (61.1%) | 23 (62.2%) | 45 (61.6%) |  |
| Anterior | 15 (41.7%) | 8 (21.6%) | 23 (31.5%) | (P = .08) |
| Posterior | 21 (58.3%) | 29 (78.4%) | 50 (68.5%) |  |
| Plaque index |  |  |  |  |
| No | 25 (69.4%) | 5 (13.5%) | 30 (41.1%) | **(P < .001)** |
| Yes | 11 (30.6%) | 32 (86.5%) | 43 (58.9%) |  |
| Bleeding on probing |  |  |  |  |
| No | 22 (61.1%) | 22 (59.5%) | 44 (60.3%) | (P = 1) |
| Yes | 14 (38.9%) | 15 (40.5%) | 29 (39.7%) |  |
| Suppuration |  |  |  |  |
| No | 36 (100%) | 23 (62.2%) | 59 (80.8%) | **(P < .001)** |
| Yes | 0 (0%) | 14 (37.8%) | 14 (19.2%) |  |
| Maintenance |  |  |  |  |
| No | 17 (47.2%) | 25 (67.6%) | 42 (57.5%) | (P = .1) |
| Yes | 19 (52.8%) | 12 (32.4%) | 31 (42.5%) |  |
| bone loss | 2.3 ± 0.5 mm | 4 ± 0.5 mm |  | **(P < .001)** |
| probing depth | 4.1 ± 0.5 mm | 5.7 ± 0.8 mm |  | **(P < .001)** |

**3.1 Bone Loss**

The bone loss was higher in posterior implants, with an average of 3.3 mm, minimum 1.7 mm and maximum 5.0 mm (P = .03). For implants diagnosed with peri-implantitis, the average was 4.0 mm, minimum 3.2 mm and maximum of 5.0 mm (P < .001). For the presence of biofilm, the average was 3.6 mm (P < .001) and average for suppuration as 4.0 mm.

The plaque index was positive for 43 out of the 73 implants. The average bone loss for 43 implants, with the presence of plaque, was 3.6 mm, minimum of 1.6 mm and a maximum of 5.5 mm (P < .001). From the implants that presented suppuration, a total of 14, the average of bone loss was 4.0 mm (P < .001). It is possible to observe on table 2 that bleeding on probing and maintenance did not present statistical differences regarding bone loss. However, bone loss was associated with position, posterior implants, and the presence of biofilm and suppuration, presenting a statistical significance level of 5%, which shows a correlation between bone loss and the respective previously mentioned variables.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |
| Variable | N | Average | SD | CI | Min | 1Quartile | Median | 3Quartile | Max | p |
| Peri-implantitis | 37 | 3.99 | 0.53 | 1 | 3.2 | 3.5 | 3.9 | 4.5 | 5 | **p < 0.001** |
| Health | 36 | 2.33 | 0.46 | 0.525 | 1.6 | 2.1 | 2.2 | 2.625 | 3.8 |  |
| Upper | 28 | 3.20 | 0.96 | 1.3 | 1.6 | 2.525 | 3.05 | 3.825 | 4.8 |  |
| Lower | 45 | 3.15 | 0.99 | 1.9 | 1.6 | 2.1 | 3.3 | 4 | 5 | p = 0.802 |
| Anterior | 23 | 2.83 | 1.06 | 1.45 | 1.6 | 2.1 | 2.6 | 3.55 | 4.8 | **p = 0.03** |
| Posterior | 50 | 3.33 | 0.89 | 1.4 | 1.7 | 2.6 | 3.45 | 4 | 5 |  |
| Plaque index  No | 30 | 2.58 | 0.76 | 0.675 | 1.6 | 2.1 | 2.4 | 2.775 | 4.5 | **p < 0.001** |
| Yes | 43 | 3.59 | 0.89 | 1.1 | 1.6 | 3.25 | 3.6 | 4.35 | 5 |  |
| Bleeding probing  No | 44 | 3.20 | 0.94 | 1.45 | 1.6 | 2.375 | 3.5 | 3.825 | 5 | p = 0.655 |
| Yes | 29 | 3.13 | 1.04 | 1.9 | 1.6 | 2.1 | 3.2 | 4 | 4.8 |  |
| Suppuration  No | 59 | 2.97 | 0.93 | 1.65 | 1.6 | 2.1 | 2.7 | 3.75 | 5 | **p < 00.01** |
| Yes | 14 | 4.03 | 0.61 | 1.075 | 3.2 | 3.5 | 4.2 | 4.575 | 4.8 |  |
| Maintenance  No | 42 | 3.35 | 0.97 | 1.525 | 1.6 | 2.475 | 3.5 | 4 | 5 |  |
| Yes | 31 | 2.94 | 0.93 | 1.5 | 1.6 | 2.1 | 2.6 | 3.6 | 4.6 | p = 0.069 |

N: implants; ST: standart deviation; CI: confidence interval, Min: minimum; Max: maximum

Table 2: bone loss observed at implants and related variables

**3.2 Probing Depth**

When assessing the variables individually, and not together, the superior or inferior positions, and bleeding on probing seem not to affect PD (probing depth), while anterior and posterior positions and plaque index do. Therefore, PD seems to be higher in posterior teeth in comparison to anterior ones, and lower when there is no plaque index, when compared to the occurrence of this index, respectively. The implant was diagnosed with peri-implantitis, and presence of biofilm has affected the PD. With a positive plaque index, the probing depth was 5.3 mm, minimum of 3.5 mm and maximum of 7.0 mm (P < .001). Bleeding on probing was not statistically significant for this group. (Table 3)

In order to compare patients with different characteristics regarding the odds of having disease, the odds ratio were calculated, which is the result of dividing the odds of a patience in a certain category of a categorical variable to have the disease by the odds of a patience in the reference category. Besides Odd Ratio, the Interval of 95% and the p-value of Fisher’s Exact Test, which tests if the Odd Ratio is statistically different from one. According to the obtained results, it is expected that the odds for peri-implantitis when there is a plaque index (PI = 1) 14.545 (P < .001 and CI = [4.472;47.313]) times the odds of having peri-implantitis when there is no plaque index (PI = 0) (table 4).



Table 4: OR for variables related to probing depth.

|  |  |  |  |
| --- | --- | --- | --- |
| variables to develop PD |  |  |  |
| Plaque index | 14.545 | [4.472;47.313] | **p ˂ 0.001** |
| Probing depth ≥4 mm | Inf. | Inf. | **p < 0.001** |

PD: probing deepth

4. discussion

Since 2017, two risk factors for peri-implantitis have been established: the prior history of periodontal disease and the inefficient daily biofilm control. Smoking and diabetes as potential risk factors are considered inconclusive [10, 11]. Host factors are equally important in the event or severity of the disease, since it is a multifactorial disease. Although the prognostic of dental implants in edentate patients is favorable in longitudinal studies, there are several evidences indicating that the installation of implants in patients with a history of periodontal problems may bring an increased risk of implant failure in the long term [13, 14, 15, 16].

With the objective of verifying the influence of clinical and variables in bone loss for implants with peri-implantitis and healthy ones, this study with 73 unitary implants has observed the prevalence of 50.7% and 49.3% respectively. A similar study - although without the established classification of peri-implant disease, has found a percentage of 54% of implants with peri-implantitis [17]. Another study has assessed the influence of clinical variables in the peri-implant condition in 75 patients and 269 implants, and it has diagnosed 115 implants with peri-implantitis (42.75%) [18]. In other studies, the prevalence of peri-implantitis was 28% [19], 9.1% [20], and 5% [21]. In these last two studies with low indicators of peri-implantitis, the patients were part of a strict maintenance program.

The position of the implant can be considered a predisposing factor to peri-implantitis due to the main factors below: (1) inadequate access to perform the correct oral hygiene; (2) excessive physiological bone remodelling when the safe distance between two adjacent implants or one implant and adjacent dentition is not respected; (3) the implant’s diameter; (4) the shape of the prosthetic crowns; (5) immediate loading; (6) bone defect; and (7) insertion torque [22, 23]. Thus, the prostheses must be projected in a way to facilitate access to regular probing diagnosis, as well as personal and professional hygiene practices [24, 25]. In this study, from the implants inserted in the posterior areas, most were diagnosed with peri-implantitis, even though it did not represent a statistical difference. In agreement with our study, implants in posterior positions were more susceptible to peri-implantitis, with a higher plaque index, bleeding and probing depth [6, 18, 26, 27]. Nonetheless, literature shows, in other studies, that the position of the implants would be a risk factor; however, with a higher risk for the anterior implants [22, 28, 29, 30].

The peri-implant bone loss has been reported as the most important predictive criterion for the success of the treatment with osseointegrated implants [1, 31, 32]. Immediately after the installation of the implants and for several months, a series of cellular and molecular events takes place. The bone remodelling mechanism for a strange body (osseointegrated implant) is induced by RANKL, which promotes the activation of the macrophages in osteoclasts. Therefore, when an early bone loss occurs, the microstructures of the implants are exposed and there is a contamination with bacteria and their subproducts (4). In this study, we assessed the distance between the bone crest and the implant’s platform. The average values for bone loss in healthy and ill implants were 2.3 and 4.0 mm, respectively, with a significant difference (p < 0.001). In a study with 142 implants, the bone loss was 4.29 mm for the implants diagnosed with peri-implantitis [30]. When assessing the 68 implants, amongst the ones diagnosed with the disease, the bone loss was ˃ 4.0 mm [27].

In this study, the average probing depth was 5.7 mm for implants with the disease and 4.1 mm for healthy ones. In the study with 262 implants, the probing depth was 2.61 ± 1.21 mm for healthy implants and 4.58 ± 1.71 mm for those with peri-implantitis. In other studies, the probing depth was 4,2 ± 1,31 mm [23], and 4.91 mm for implants diagnosed with peri-implantitis [18]. When assessing 75 patients with 269 implants, 63 of them were diagnosed with peri-implantitis, and their probing depth was 4.91 mm [33].

Bleeding on probing was not associated with the presence of peri-implantitis, bone loss and probing depth in this study. However, the literature reports that bleeding on probing is a way to early diagnose peri-implantitis. Implants presenting bleeding had a likelihood of 24.1% to be diagnosed with peri-implantitis [25, 34]. We have observed that 40.5% of the implants diagnosed with peri-implantitis presented bleeding. In a study with 482 implants assessed during 10 years, the index of bleeding on probing was 93.9% [19]. In a multi-centric study with 117 patients and 295 installed implants, the bleeding in probing index was 54.9% [35]. Similarly to our results, a randomized clinical study with 41 patients with the absence of a dental element in the posterior region of the upper maxilla did not present statistical differences between the bleeding index and the other clinical variables assessed [17].

In the study, out of the 37 implants (50.7%) diagnosed with peri-implantitis 32 of them (86.5%) presented positive for plaque index in the clinical evaluation. The positive plaque index was statistically significant with the disease’s variables of bone loss and probing depth. In other studies, that percentage was 82.8% [19], 61% [30], 83.3% [35]. The literature reports substantial evidences to indicate the accumulation of biofilm as an etiologic factor for peri-implant diseases [4, 16, 36, 37, 38].

On the other hand, it is widely discussed that the lack of oral hygiene and the poor adhesion to the maintenance therapy may lead to peri-implant diseases [39]. Biofilm is the most important etiological agent to start and progression the peri-implant diseases. However, studies have not yet identified the level of biofilm control compatible with the maintenance of the peri-implant health. As seen in this study, there are evidence of an increased risk of developing peri-implantitis when patients have low capacities to control bacterial plaque and lack regular maintenance after the implant therapy [40]. This suggests that it is important to carefully monitor changes that may occur around dental implants in the early post-restorative phase, with focus on bleeding on probing/suppuration and in combination with radiographic evidence of bone loss [8].

The study has some limitations, such as the absence of baseline radiographic and probing data, and the certainty of carrying out maintenance consultations on the implants, as it was dependent on patient responses, factors that limit generalization.

Based on our results, the annual maintenance has not been statistically significant, and a possible explanation is that there may be an uneven distribution of patients who go to the maintenance appointments regularly and those who do not. Although no major changes were observed between patients who perform annual maintenance and those who do not perform annual maintenance, maintenance consultations are essential for a favorable prognosis of dental implants. Biofilm control is essential for the preservation of peri-implant tissues and, depending on the microorganisms involved, host response and other factors such as smoking, diabetes, and inadequate hygiene, we may have the development of disease. Another reported hypothesis is that the oral hygiene maintenance is not influenced just by the patient’s adhesion, but also by the qualifications and the experience of the dental professionals that provide the preventive treatment [41]. Another factor to be considered is that there is no evidence-based guideline or protocol about preventing peri-implant diseases [42]. Patients often think that by going to the maintenance appointments, the maintenance will be duly performed, but that is not usually the case. Most of the time, the dentist only visually examines the patient, believing that everything is fine and making the patient believe this too without performing peri-implant probing or imaging exams.

5. Conclusion

Within the limitations of this cohort study, increased plaque index and suppuration were significantly associated with peri-implantitis. Prospective studies with baseline measurements should be performed to elucidate the role of biofilm in peri-implantitis.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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