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Clinical Characteristics and Factors Associated with Peri-Implantitis: A Comparative Analysis

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Abstract

Background. *The clinical condition of the tissues surrounding a dental implant reflects the interplay of the microbial biofilm, soft-tissue characteristics, patient hygiene behavior, implant function time, and local conditions of the implant rehabilitation. Quantitative characterization of these parameters is important for objectifying the clinical phenotype of peri-implantitis and for the early detection of adverse changes [1–6].*

Aim. *To assess the differences in clinical and implant-related parameters between patients with and without peri-implantitis.*

Methods. *The study included 414 patients with dental implants, of whom 330 had no signs of peri-implantitis and 84 had a documented diagnosis of peri-implantitis. The following parameters were assessed: the Simplified Oral Hygiene Index (OHI-S), the peri-implant plaque index (PI), bleeding on probing, suppuration, probing depth (PD), the width of keratinized mucosa, marginal bone loss, implant function time, the number of implants, and the number of implants with signs of mucositis. Quantitative variables were compared between groups using non-parametric methods, and categorical variables using the chi-squared test. Multivariable logistic regression was used to identify the clinical characteristics independently associated with peri-implantitis. PD and marginal bone loss (mm) were treated primarily as characteristics of the clinical phenotype and were not used as independent aetiological predictors of the disease.*

Results. *Patients with peri-implantitis showed poorer oral hygiene, higher plaque index and probing depth (PD 3.76 ± 0.96 vs 1.46 ± 0.66), greater marginal bone loss, and a narrower zone of keratinized mucosa. The mean OHI-S score was 4.69 ± 0.57 versus 1.92 ± 0.98 in the group without peri-implantitis, and the peri-implant plaque index was 2.86 ± 0.35 versus 1.41 ± 0.87. Marginal bone loss was 3.52 ± 0.61 versus 1.22 ± 0.56 mm, whereas the width of keratinized mucosa was smaller in the peri-implantitis group (1.89 ± 0.66 vs 3.39 ± 0.95 mm). All these differences were statistically significant ($p < 0.001$).*

Implant function time was longer in patients with peri-implantitis: 7.52 ± 1.21 versus 4.82 ± 1.70 years ($p < 0.001$). These patients also had a larger number of placed implants and of implants showing signs of peri-implant mucositis.

Conclusions. *In the study cohort, peri-implantitis was characterized by a complex of clinical changes, including poorer oral hygiene, more pronounced signs of inflammation, increased peri-implant probing depth, greater bone loss, and a reduced width of keratinized mucosa. The combination of local parameters and implant function time may be used for the clinical stratification of an adverse peri-implant status.*

Keywords: **Peri-implantitis; peri-implant tissues; dental implants; OHI-S; plaque index; probing depth; bone loss; keratinized mucosa**.

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1. Introduction

The peri-implant tissues constitute a dynamic biological system whose state depends on the interplay between the microbial biofilm and the innate and adaptive immune response, the anatomical features of the soft tissues, and the functional load on the implant. When the peri-implant tissues are stable, the inflammatory response is absent or minimal, whereas a disruption of the microbiological equilibrium and inadequate biofilm control may lead to the development of mucositis and, in susceptible patients, of peri-implantitis [1–5].

According to the current consensus, peri-implant mucositis is characterized primarily by inflammation of the soft tissues and bleeding on probing, whereas peri-implantitis is an inflammatory disease accompanied by progressive loss of the supporting bone [1]. The assessment of the peri-implant tissues should therefore include a set of clinical parameters, including probing depth, the presence of bleeding and suppuration, and the condition of the bone surrounding the implant.

Studies have shown that the risk of detecting peri-implantitis increases with longer implant function time and depends on the diagnostic criteria applied [6, 7, 14]. When analysing clinical data, the duration of implant function must therefore be taken into account, since different local and systemic factors may act on the peri-implant tissues over different periods of time.

One of the central elements of the pathogenesis is the microbial biofilm. Experimental studies have shown that plaque accumulation around implants elicits an inflammatory response in the soft tissues, and inadequate biofilm control contributes to the persistence of the inflammatory process [8, 9]. Quantitative assessment of the hygiene status and the level of plaque is therefore an important component of the clinical characterization of patients.

The condition of the soft tissues is of no lesser importance. In particular, the width of the keratinized mucosa is regarded as a potential modifier of peri-implant health. Current systematic reviews indicate a higher prevalence of peri-implantitis in the absence or insufficiency of keratinized mucosa [10, 11, 17, 30]. At the same time, the results of current studies do not allow its direct causal effect to be confirmed unambiguously, which underlines the need to take other factors into account in clinical studies [1].

Probing depth, bleeding, and bone loss have considerable diagnostic value [13]. However, it is incorrect to regard these parameters as independent causes of peri-implantitis, since the combination of inflammation and bone loss constitutes the basis of the diagnosis of this disease [1, 12]. In the present study, these parameters are therefore considered as characteristics of the clinical presentation of peri-implantitis, whereas the potential factors that may influence its development are analysed separately.

Implant function time may also be of relevance: the longer the implant remains in the oral cavity, the longer the microbial biofilm and other local factors act on the surrounding tissues. Systematic reviews show that the frequency of peri-implantitis increases with longer implant function time [6, 7, 14].

Supportive care is another essential component of long-term peri-implant health. Current recommendations provide for regular clinical examination, professional removal of the biofilm, and individualized hygiene support after implant placement and loading [15, 18, 19, 20]. Inadequate adherence to supportive care is associated with less favorable peri-implant outcomes [18, 19, 20].

The clinical characterization of peri-implantitis should therefore be based on a comprehensive assessment of the hygiene status, inflammatory manifestations, the condition of the soft and hard tissues, and the duration of implant function.

The aim of the present study was to assess the differences in clinical and implant-related parameters between patients with and without peri-implantitis.

2. Methods

The study was based on a retrospective clinical database of patients with dental implants. Of the 444 initial records, only patients with a documented clinical outcome were

included in the analytical sample. After the exclusion of 30 records without an outcome code (Outcome code), the final analysis was performed on 414 patients.

According to the clinical status, 330 patients were assigned to the group without peri-implantitis and 84 to the peri-implantitis group.

The Simplified Oral Hygiene Index (OHI-S) was used for the quantitative assessment of the hygiene status. In addition, the peri-implant plaque index (PI) was assessed. The condition of the peri-implant tissues was characterized by the presence of bleeding on probing, suppuration, and the peri-implant probing depth.

The condition of the hard tissues was assessed by the magnitude of the bone loss recorded in the clinical database. The width of the keratinized mucosa was additionally recorded.

Since PD, bleeding on probing (BOP), suppuration, and bone loss are components of the clinical characterization of peri-implantitis, they were interpreted as indicators of the disease phenotype rather than as independent causal factors.

The analysis included the number of implants per patient, their function time, the implant length and diameter, the jaw and anatomical zone, the type of loading, and the type of fixation of the prosthetic reconstruction.

Quantitative variables are presented as means and standard deviations. Between-group comparisons were performed using the Mann–Whitney U test; categorical variables were analyzed using the chi-squared test.

To assess the independent association between the clinical and implant-related characteristics and the presence of peri-implantitis, multivariable logistic regression was used. The model included parameters that were not themselves components of the diagnostic definition of the disease: the OHI-S, the peri-implant plaque index, the width of keratinized mucosa, the implant function time, the number of implants, and the presence and number of sites with mucositis.

PD, BOP, suppuration, and bone loss were not included in the aetiological model, since their inclusion would have introduced circularity between the diagnostic definition of the disease and its predictors.

3. Results and Discussion

The most pronounced differences between the groups were observed for the hygiene and plaque accumulation indices.

The mean OHI-S score in patients without peri-implantitis was 1.92 ± 0.98, compared with 4.69 ± 0.57 in patients with peri-implantitis; the difference was statistically significant ($p < 0.001$).

A similar pattern was found for the peri-implant plaque index: 1.41 ± 0.87 in the group without the disease versus 2.86 ± 0.35 in the peri-implantitis group ($p < 0.001$).

The presence of peri-implantitis in the study cohort was thus accompanied by a considerably less favorable hygiene and biofilm profile.

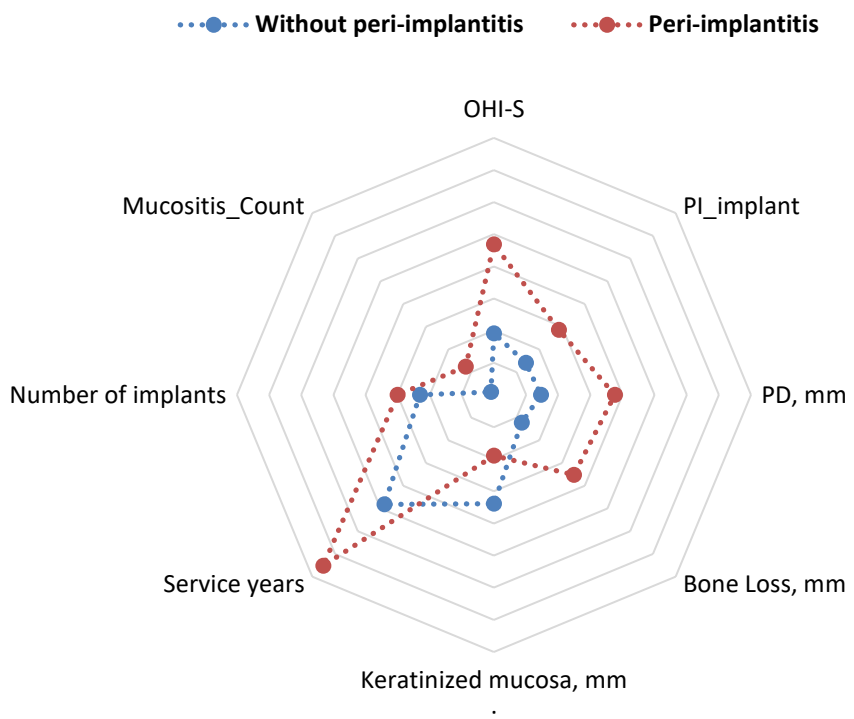

Figure 1. Main clinical characteristics of the patients.

The peri-implant probing depth was significantly higher in patients with peri-implantitis: the mean PD was 3.76 ± 0.96 mm versus 1.46 ± 0.66 mm in patients without the disease ($p < 0.001$).

The magnitude of bone loss also differed substantially between the groups: in the group without peri-implantitis, the mean bone loss was 1.22 ± 0.56 mm, compared with 3.52 ± 0.61 mm in the peri-implantitis group ($p < 0.001$).

These findings demonstrate substantial clinical differences between the groups and are consistent with the current concept of peri-implantitis as an inflammatory disease accompanied by loss of the bone surrounding the implant [1, 2].

The width of the keratinized mucosa was significantly smaller in patients with peri-implantitis: the mean value was 1.89 ± 0.66 mm versus 3.39 ± 0.95 mm in patients without the disease ($p < 0.001$).

This difference is of clinical relevance, since an adequate width of keratinized mucosa may facilitate individual oral hygiene and the maintenance of soft-tissue stability. Current meta-analyses likewise demonstrate an association between insufficient keratinized mucosa and a higher frequency of peri-implantitis [10, 11].

The duration of implant function was statistically significantly longer in the peri-implantitis group: the mean value was 7.52 ± 1.21 years compared with 4.82 ± 1.70 years in the group without the disease ($p < 0.001$).

The number of implants per patient also differed between the groups: 3.00 ± 0.66 versus 2.31 ± 0.77, respectively ($p < 0.001$).

The number of implants with documented signs of mucositis averaged 1.24 ± 0.43 in the peri-implantitis group and 0.13 ± 0.41 in the group without the disease ($p < 0.001$).

Taken together, these findings allow a characteristic clinical profile of patients with peri-implantitis to be identified. It included unsatisfactory hygiene, pronounced plaque accumulation, increased probing depth, greater bone loss, a reduced width of keratinized mucosa, and a longer implant function time.

Of particular importance is that the differences were observed simultaneously across several interrelated parameters. This confirms the need to assess the peri-implant status as a multicomponent phenotype rather than as an isolated pathological sign.

In the present study, peri-implantitis was associated with a pronounced deterioration of the hygiene status and an

increased amount of plaque around the implants: the OHI-S and the peri-implant plaque index were significantly higher in patients with the disease. These results correspond to the current model of pathogenesis, in which the microbial biofilm is the key initiating factor of inflammation of the peri-implant mucosa [1, 8, 9, 16].

The presence of the biofilm alone, however, does not explain the development of peri-implantitis in all patients. The inflammatory response is determined by the interaction of the microbial challenge with individual host susceptibility, the condition of the soft tissues, systemic factors, and the effectiveness of supportive care [4, 5, 22]. A history of periodontitis and smoking are regarded as important modifiers of the risk of peri-implantitis [23, 24, 26–28], and disorders of carbohydrate metabolism may be associated with unfavorable peri-implant outcomes [25]. The characteristics of the implant surface and material are also considered potential modifiers of the risk and progression of the disease [29]. The pronounced deterioration of hygiene in the present sample should therefore be regarded as a component of a complex clinical profile rather than as the sole cause of the disease.

Probing depth and bone loss differed substantially between the groups. However, their interpretation as independent risk factors should be approached with caution. Increased probing depth and bone loss are important signs of peri-implantitis and form part of its diagnostic characterization [1, 12]. Their inclusion in a risk-factor model could therefore have artificially inflated their association with the presence of the disease. In the present study, these parameters were used primarily to characterise the clinical severity of peri-implantitis.

The mean bone loss in patients with peri-implantitis was almost three times higher than in the group without the disease. This finding corresponds to the characteristic feature of peri-implantitis – progressive bone loss around the implant [1, 2, 9, 21]. At the same time, a small degree of bone loss in patients without peri-implantitis does not necessarily indicate the absence of disease: according to the current classification, a decreased level of bone support may be observed in the absence of active peri-implantitis, especially if signs of inflammation are absent [1].

In patients with peri-implantitis, the implants had functioned significantly longer than in patients without the disease. This result is consistent with epidemiological data showing that the prevalence of peri-implantitis increases with longer implant function time [6, 7, 14]. A longer function time implies a longer exposure to the microbial biofilm, to the features of the prosthetic restoration, and to other local factors. Implant function time, however, should not be regarded as an independent cause of peri-implantitis, since it may be related to patient age and to the duration of exposure to other risk factors.

The number of implants was higher in the group of patients with peri-implantitis. This parameter probably reflects the more complex nature of implant-prosthetic treatment and the need for more intensive supportive care. Its value should be assessed together with the characteristics of the implant reconstruction and the oral hygiene status.

A considerable difference between the groups was also observed for the number of implants with signs of mucositis: in the peri-implantitis group it was almost ten times higher. This result corresponds to current concepts of the interrelation between peri-implant mucositis and peri-implantitis, since long-standing inflammation of the soft tissues may, under certain conditions, be accompanied by involvement of the bone [1, 9, 16, 21]. The presence of mucositis, however, does not imply the inevitable development of peri-implantitis. The detection of mucositis should therefore be regarded as an indication for timely preventive and supportive treatment [1, 9, 16, 21].

These findings have direct practical relevance. Current recommendations of the European Federation of Periodontology (EFP) provide for regular examination of the peri-implant tissues and individualized supportive care after implant placement [13]. Systematic reviews show that the absence or insufficiency of supportive care is associated with less favorable clinical outcomes and a higher frequency of signs of inflammation [18–20].

Overall, the findings indicate that peri-implantitis is characterized by a combination of several clinical changes. Their combined assessment is the most informative, encompassing the level of plaque, the oral hygiene status, signs of inflammation, probing depth, the width of keratinized mucosa, the magnitude of bone loss, and the implant function time.

The retrospective design of the study limits the possibility of establishing a temporal sequence between individual clinical characteristics and the development of the disease. Moreover, some of the parameters are interdependent and reflect different aspects of the same pathological process.

It is important to note that probing depth (PD), bleeding on probing (BOP), suppuration, and bone loss are the principal clinical signs of peri-implantitis. Their simultaneous inclusion in a prognostic model together with the presence

of peri-implantitis would have artificially increased the diagnostic significance of these parameters. In the present study, these parameters were therefore regarded as characteristics of the clinical presentation of the disease, whereas the potential independent factors were analyzed separately.

In addition, the final model did not include immunological and microbiological parameters. Their further study will make it possible to assess the relationship between the clinical presentations of peri-implantitis and the features of the local inflammatory response and the microbial composition of the peri-implant area.

4. Conclusion

In the study cohort, peri-implantitis was accompanied by a combination of unfavorable clinical changes. Patients with peri-implantitis showed higher OHI-S and plaque index values, increased probing depth and bone loss, a narrower zone of keratinized mucosa, a larger number of implants, and a longer implant function time.

The findings show that the assessment of the peri-implant tissues should take into account several groups of parameters, including the level of hygiene, signs of inflammation, the condition of the soft and bone tissues, and the duration of implant function. This comprehensive approach may be used in the future to develop a more accurate assessment of the risk of peri-implantitis.

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