Peri-implant pathology: the prevalence(s) of the condition, the risk model(s) of the condition

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Dental implants long term success rely on the establishment of a stable condition. This stability may be negatively influenced by the coexistence of peri-implant pathology, provoking loss of the supporting bone tissue around the implant. A large range in the prevalence of this condition is observed when analyzing different reports in the literature given the different definitions for peri-implant pathology. The background for this investigation was the assumption that peri-implant pathology is a group of multifactorial situations with several potential non-sufficient, non-necessary causes and the absence of risk models to aid the decision process in the maintenance of implant supported restorations. We explored these important aspects and investigated potential risk factors and statistical models for peri-implant pathology based on a model of sufficient and component causes. We found that biological and biomechanical factors can be involved as causal mechanisms of peri-implant pathology. Our study established three different statistical models based on binary conditional regression analysis, with the representative model presenting high sensitivity, specificity and accuracy, providing high positive and negative likelihood ratios. This model will represent a valid tool for the clinician in the maintenance of implant-supported fixed prosthetic rehabilitations.

Keywords: Peri-implant pathology; bone loss; statistical modeling; risk; dental implants

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“Peri-implantitis” was defined in 1984 as "the term for inflammatory reactions with loss of supporting bone tissue surrounding the implant in function" [1]. It is considered to be the major cause of dental implant failure after the completion of osseointegration [2].

Concerning the etiopathogenesis, two distinct pathways were first described, classical and retrograde, containing factors of biological and biomechanical origin [3-5]: The classical pathway was described by a mechanism where bacterial plaque was the major risk factor, producing an inflammatory reaction that could result in the breakdown of the peri-implant complex, and consequent implant failure [3, 4]; a retrograde pathway (from the bone to the soft tissue) was suggested to be associated with overload and occlusal factors [5].
There is no consensus around, the term “peri-implantitis”,
classical pathogenic mechanisms and their respective causes.

A recent editorial by Zarb et al. [6] highlighted the
criticism of the use of the term “peri-implantitis” since it
implied a disease process similar to periodontitis,
emphasizing that the vacuum created by the incomplete
understanding of the implant-host should not be filled with
the reasonably coherent understanding of the tooth-host
interface. This suggestion for separating periodontitis and
peri-implant pathology was proposed at least one decade ago
[7] and was recently supported by genetic investigations [8,9].
Furthermore, the classical pathogenesis mechanisms for
peri-implant pathology have been recently challenged, with
the proposal of different concepts for the outcome marginal
bone loss. One of the theories comprises the foreign body
reaction to dental implants (the rejection mechanism derived
from an immunological origin) [10, 11]. Another theory
suggests the influence of the clinicians performing the
rehabilitation (from a surgical as well as a prosthodontic
perspective) [12]. Moreover, it is subject of debate which
factors contribute to peri-implant pathology.

The prevalence of peri-implant pathology is reported in
the literature with a range between a low prevalence of 5% and
up to a prevalence as high as 56% [13-19]. The reason for
these different figures concerns the different definitions used
for classification, making it difficult to compare between
studies and therefore reinforcing the need for more studies
and consensus on this subject.

Whether other possible risk factors could play a role in the
pathogenesis of peri-implant pathology needs to be
investigated. This was the background for the
epidemiological methodology developed for investigating
risk factors for peri-implant pathology, based on a sufficient
and component causes model suggested by Rothman and
Greenland [20]. This methodology considers that the condition
could be caused by more than one causal mechanism; each
composed of several component causes. Our data reflected
this approach, with peri-implant pathology considered as a
group of multifactorial situations with several potential
non-sufficient, non-necessary causes i.e., the incidence
depends on the interaction of multiple factors [21].

To accomplish the objectives of investigating potential
risk factors and creating a model to predict peri-implant
pathology, a sample of 1275 patients was analyzed using a
case-control study design and binary logistic regression.

The rationale for creating more than one model was based
on the proposed outcome of using predictive models for
peri-implant pathology and considering the statistical
limitations of inserting too many variables in a single model,
yielding a statistical bias [22]. The first model (Model 1)
represented a simpler model with six variables; the second
model allowed the discrimination between the type of
implant surface (machined or anodically oxidized) and higher
specificity (Model 2 with 8 variables and 1 interaction);
while the third model had a higher sensitivity and overall
balanced accuracy (Model 3 with 8 variables and 1
interaction) and was chosen as representative (Table 1) [21].

Common to the three models, the predictors for
peri-implant pathology were history of periodontitis, lack of
prosthetic fit or non-optimal screw joint, bacterial plaque,
and bone level; common to Models 1 and 3, the predictor
bleeding; common to Models 2 and 3, the predictors type of
material used in the prosthesis, proximity of the implant to
other teeth or implants, and the interaction between bacterial
plaque and proximity of the implant to other teeth or
implants; and only included in one of the models, the
predictor machined implant surface (Model 2).

Our study established peri-implant pathology as a group of
multifactorial situations caused by more than one mechanism,
with each sufficient cause (enough for peri-implant
pathology to manifest itself clinically) being composed of
different component causes. This fact is illustrated by the
analysis of the 10 most prevalent sufficient causes identified
in our data using the variables retrieved from our model
(Figure 1), suggesting different combinations of component
causes in each sufficient cause, representing 77 patients of
our sample.

<table>
<thead>
<tr>
<th>Models</th>
<th>Cut-off value</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Balanced Accuracy (Sensitivity+Specificity)/2</th>
<th>Likelihood Ratio Sensitivity/(1-Specificity)</th>
<th>Ratio</th>
<th>Likelihood Ratio (1-Sensitivity)/Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Optimum (0.33)</td>
<td>0.847</td>
<td>0.909</td>
<td>0.878</td>
<td>9.31</td>
<td>0.168</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Optimum (0.30)</td>
<td>0.878</td>
<td>0.911</td>
<td>0.895</td>
<td>9.87</td>
<td>0.134</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Optimum (0.31)</td>
<td>0.882</td>
<td>0.909</td>
<td>0.896</td>
<td>9.69</td>
<td>0.129</td>
<td></td>
</tr>
</tbody>
</table>

- Model 1: History of periodontitis; lack of prosthetic fit or non-optimal screw joint, bacterial plaque, bone level, smoking habits, bleeding.
- Model 2: History of periodontitis; lack of prosthetic fit or non-optimal screw joint, bacterial plaque, bone level, smoking habits, type of material used for restoration, machined implant surface, proximity of other teeth or implants.
- Model 3: History of periodontitis; lack of prosthetic fit or non-optimal screw joint, bacterial plaque, bone level, smoking habits, bleeding, type of material used for restoration, proximity of other teeth or implants.

Table 1. Statistical measures of performance for the three models: positive and negative likelihood ratios according to the sensitivity and specificity of the three models at the optimum cut-off values

[Page 2 of 4]
The model yielded high sensitivity and specificity. Sensitivity and specificity are important parameters in clinical epidemiology to allow evaluating a clinical test, as they are independent of the population of interest subjected to the test and not influenced by the prevalence of the disease [23]. Sensitivity refers to the ability of the test or procedure to correctly identify those patients with the disease, while specificity refers to the ability of the test or procedure to correctly identify those patients without the disease [24]. Considering any given clinical test, the ideal situation would be to have 100% sensitivity (identifying all diseased patients) and 100% specificity (identifying all disease free patients), although the situation is unrealistic, and usually to a higher sensitive test corresponds a lower specificity [24]. Sensitivity and specificity cannot be used to estimate the probability of disease in an individual patient. Nevertheless, the likelihood ratio (LR) [24] provides clinical information about the number of times a patient with the disease is more (positive) or less (negative) likely to have the result when compared to a patient without the disease [24]. The three models rendered different LR+ and LR- values. Considering the LR+ at the optimum cut-off point, a patient with peri-implant pathology was 9.31 times (Model 1), 9.87 times (Model 2) and 9.69 times (Model 3) more likely to have a positive test compared to a patient without peri-implant pathology; while considering the LR- at the same cut-off point, patients without peri-implant pathology were about 5.95 times (Model 1), 7.46 times (Model 2) and 7.75 times (Model 3) more likely to have a negative test than individuals with peri-implant pathology.

In summary (Figure 1), peri-implant pathology is characterized by multifactorial situations. Our data demonstrate that peri-implant pathology may be influenced by several risk factors following a model of sufficient and component causes [20]. This renders that different models can be created to modulate peri-implant pathology given the potential different combinations of risk factors in different populations. We are currently investigating the process of updating and strengthening the model while transforming the complex statistical regression calculations into risk scores that could represent a valid tool to aid the clinician in the decision process when maintaining implant supported rehabilitations.

Conflicting interests

The authors have declared that no conflict of interests exists.
Abbreviations

LR+: Positive likelihood ratio; LR-: negative likelihood ratio.

References