Parameters to Define Peri-Implantitis: A Review and a Proposed Multi-Domain Scale

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Peri-implant diseases have received much attention since dental implants are generally used in contemporary dentistry. Several contributing factors associated with the development of peri-implant diseases have also been investigated. The prevalence of peri-implantitis has been reported but with great heterogeneity because of a lack of a universally accepted classification system that could define the extent and severity of peri-implantitis. Several parameters—including radiographic bone loss, probing depth, bleeding on probing, and suppuration—have been introduced in these reports to assist with clinical diagnosis. This article provides an objective evaluation of these parameters based on currently available evidence, offers further recommendations, and proposes a multidomain scale for diagnosis of peri-implantitis. Future investigations and modifications may be needed to develop a comprehensive, evidence-based classification system that addresses the multifactorial etiology of peri-implant diseases.

Key Words: dental implants, peri-implantitis, periodontal pocket, implant-supported dental prosthesis, risk factors

INTRODUCTION

Peri-implant diseases have received much attention since dental implants began extensive use in contemporary dentistry.1–3 The American Academy of Periodontology Academy Statement3 defines peri-implant mucositis as the presence of inflammation confined to the soft tissues surrounding a dental implant with no signs of bone loss following initial bone remodeling. Peri-implantitis is defined as an inflammatory process around an implant, which includes both soft tissue inflammation and progressive bone loss following initial bone remodeling.3 The etiology of peri-implant diseases is multifactorial. Similar to the etiology of gingivitis and periodontitis, the primary etiology of peri-implant diseases is reported to be bacterial in nature with subsequent activation of the host immune response.3–5

Several contributing factors associated with the development of peri-implant diseases have also been investigated, including but not limited to a history of periodontitis,6,7 smoking,8,9 and residual cement.10 In addition, occlusal overload is often as a significant factor when bone loss is observed proximal to dental implants.11 Other factors that have been linked to peri-implant bone loss are implant malposition,12 compression necrosis,13 and even foreign body reaction.14 However, these remain controversial with regards to their true association with peri-implant bone loss or even peri-implantitis.

The prevalence of peri-implantitis has been widely reported but with great heterogeneity.3,15 Since there is no universally accepted classification system to define the extent and severity of peri-implantitis, most clinical publications define a disease status based on their own criteria (Table 1).16–31 According to these publications, the prevalence of peri-implantitis ranges from 6.2% to 39.3% at the implant level and 10.5% to 47.8% at the patient level. Several parameters have been introduced in these reports to assist with clinical diagnosis. Among the most widely used parameters are radiographic bone loss (RBL), probing depth (PD), bleeding on probing (BOP), and suppuration. This article’s goal is to provide an objective evaluation of these parameters based on currently available evidence, provide further recommendations, and propose a multidomain scale for future diagnosis of peri-implantitis.

RADIOGRAPHIC BONE LOSS

Peri-implant bone loss is the major criterion that differentiates peri-implantitis from peri-implant mucositis. As a result, radiographic bone loss (RBL) is introduced to determine the peri-implant bone level due to its convenience and lack of invasiveness. However, there is no consensus on the ideal threshold of RBL that defines disease status. In 1986, Albrektsson et al12 proposed that a successful implant must present no mobility, no peri-implant radiolucency, bone loss of less than 0.2 mm per year after the first year of loading, and no persistent pain, discomfort, or infection. In their study, the authors reported 1 mm of RBL during the first year after abutment connection. It is important to note that the authors proposed these criteria based on observations made on pure...
been analyzed.\textsuperscript{2,3,15,21,28,35} A recent animal study reported that and microdesigns, and implant surface topography—have all dictability of the amount of RBL are still not fully understood.

Several factors—including the level of implant placement, depth of implant penetration, shoulder) to define “acceptable” bone remodeling is challeng-

er.\textsuperscript{2,25} Consequently, the prevalence of peri-implantitis report-

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ed throughout the literature is inconsistent because of the diverse cut-off values for RBL defined in individual studies.

Most recent studies introduced the concept of 2 mm of bone loss from a fixed point (such as the implant shoulder, the platform level, or the most apical extension of the polished surface) as the reference point from which to measure the RBL after the first year of loading (Table 2). However, this definition often makes clinical diagnosis difficult since the amount of physiologic bone remodeling cannot be predicted from the reference point due to its multifactorial nature. To date, the only consensus report aiming to define this threshold is the VIII European Workshop on Periodontology.\textsuperscript{2} In this consensus report, \textit{peri-implantitis} was defined as “changes in the level of the crestal bone in conjunction with BOP with or without concomitant deepening of peri-implant pockets”\textsuperscript{36} if a baseline radiograph is available. However, in the absence of previous radiographic records, a threshold of 2 mm of vertical bone loss from the expected marginal bone level was suggested.

Although this report provides a clear diagnostic guideline for clinicians, other issues such as “expected marginal bone level” and “acceptable amount of annual bone loss” after the first year of loading are subjective. One study suggested that “RBL >2 mm from the implant platform for bone-level implants or >2 mm from the apical termination of the polished collar for tissue-level implants” could be used as the threshold indicating

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|c|c|c|c|c|c|c|}
\hline
Author(s) & Prevalence & Prevalence & Baseline Bone & Follow-up & RBL & Probing & Thresholds \\
& (Implant Level) & (Patient Level) & level & (years) & & & \\
\hline
Fransson et al\textsuperscript{16} & 12.4% & 27.8% & Radiographs taken at first year after restoration & 5 & ≥3 threads & Not used & Not used & Not used \\
Ferreira et al\textsuperscript{31} & 7.4% & 8.9% & Smooth parts and threads & 3.54 ± 1.43 & Vertical RBL & >5 mm & Yes & Yes \\
Roos-Jansaker et al\textsuperscript{17} & 6.6% & 16% & Radiographs taken at first year after restoration & 9–14 & ≥3 threads & Not used & Yes & Yes \\
Koldsland et al\textsuperscript{18} & 36.6% & 47.1% & Abutment level & 7.4 ± 4.7 & ≥2 mm & >4 mm & Yes & Yes \\
Simonis et al\textsuperscript{19} & 16.94% & 10.53%–37.93% & Implant shoulder & 10–16 & >2.5 mm or >3 threads & >5 mm & Yes & Yes \\
Atieh et al\textsuperscript{20} & 9.6% & 18.8% & NA & NA & ≥2 mm or >3 threads & >5 mm & Yes & Yes \\
Meijer et al\textsuperscript{20} & 11.5% & 16.9% & Fixed reference point & 5 & >2 mm & Not used & Yes & Yes \\
Schuldt Filho et al\textsuperscript{23} & 27.95% & 29.63% & Implant platform & >5 & >2 mm & >4 mm & Yes & Yes \\
Renvert et al\textsuperscript{21} & 39.3% & 47.8% & Implant platform & 11.8 ± 3.3 & ≥2 mm & ≥4 mm & Yes & Yes \\
Aguirre-Zorzano et al\textsuperscript{22} & 9.8% & 15.1% & Radiographs taken at 6 months after restoration & 5.25 ± 3.42 & ≥1.5 mm & Increased & Yes & Yes \\
Daubert et al\textsuperscript{24} & 16% & 26% & 2 mm from the expected level & 10.9 ± 1.5 & ≥2 mm & >4 mm & Yes & Yes \\
Konstantinidis et al\textsuperscript{25} & 6.2% & 12.9% & Implant platform or apical termination of polished collar & 5.5 ± 3.8 & >2 mm & >5 mm & Not used & \\
Derks et al\textsuperscript{26} & NA & 14%–30% & Radiographs taken at up to 1 year after restoration & 9 & ≥0.5 mm & Not used & Yes & Yes \\
Schwarz et al\textsuperscript{27} & 7.6% & 13.9% & Radiographs taken at the time of restoration & 2.20 ± 1.38 & With changes & Increased & Yes & Yes \\
Dalago et al\textsuperscript{28} & 7.3% & 16.4% & Abutment level & 1–14 & >2 mm & >5 mm & Yes & Yes \\
Rokn et al\textsuperscript{29} & 8.8% & 20% & Implant shoulder & 4.43 ± 2.25 & >2 mm & Not used & Yes & Yes \\
\hline
\end{tabular}
\caption{Studies reporting the prevalence and criteria for peri-implantitis*}
\end{table}

\textsuperscript{*}RBL indicates radiographic bone loss; BOP, bleeding on probing.
Derks et al28 proposed the amount of RBL (total implant length to define the severity of peri-implantitis. Therefore, a modified scale that incorporates the 0.2 mm after physiologic remodeling could be considered acceptable.1 Therefore, a modified scale that incorporates the type of implant design and years of service would be beneficial in deriving a more uniform diagnosis.

In our proposed multidomain scale (Table 3), clinicians should evaluate whether or not a baseline radiograph taken at least 1 year after definite crown delivery is available. If this baseline radiograph is available, the acceptable RBL will be no more than 0.2 mm annually compared to the baseline radiograph. On the contrary, if a baseline radiograph is not available, a threshold of 2 mm RBL from a fixed point (eg, implant platform for bone-level and termination of polished collar for tissue-level implants) should be used to determine the disease status. It is worth taking a baseline radiograph whenever possible since it provides valuable information in terms of bone level after the physiologic bone remodeling process. The threshold of “2 mm RBL from a fixed point” should be applied only when a baseline radiograph is not retrievable. A clinical case with a baseline radiograph is demonstrated in Figure 1 as an example.

In terms of the severity of peri-implantitis, several parameters have been proposed.28,37,38 Froum and Rosen37 and Decker et al38 used the percentage of RBL relative to the total implant length to define the severity of peri-implantitis. Derks et al28 proposed the amount of RBL (>c.0.5 mm as mild/slight and c.2 mm as moderate/severe) to address the severity. A comparison of these systems and a proposed scale is listed in Table 2. Since there is no available consensus report to elaborate on this issue, we suggest using the percentage of RBL relative to the total implant length, proposed by the aforementioned articles37,38 to define severity since it is relatively objective and easy to determine radiographically.

### Probing Depth
Probing depth is another parameter that has been used to determine peri-implant tissue health. Although this parameter is reproducible and repeatable within 1 mm of accuracy at periodontal sites,39 the accuracy of PD around dental implants remains challenging. Since the reproducibility of PD depends on several factors—such as probing force, probing angulation, probe tip diameter, and tissue inflammatory status—implant-supported restorations might hinder the ability to attain accurate measurements. It has been reported that implant and abutment designs might increase difficulty in obtaining accurate PD measurements, further underestimating the extent of the peri-implant lesion.36

Due to the absence of periodontal ligament fibers, supracrestal connective tissue fibers are arranged in a circular pattern40,41 around the peri-implant tissues, thus decreasing the resistance to clinical probing compared to natural

<p>| TABLE 2 |
| Currently available scales defining peri-implantitis* |</p>
<table>
<thead>
<tr>
<th>Authors</th>
<th>RBL</th>
<th>PD</th>
<th>BOP and/or Suppuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Froum and Rosen37</td>
<td>Early: c.25% of the implant length</td>
<td>c.4 mm</td>
<td>BOP and/or suppuration</td>
</tr>
<tr>
<td>Moderate: 25% to 50% of the implant length</td>
<td>c.6 mm</td>
<td>BOP and/or suppuration</td>
<td></td>
</tr>
<tr>
<td>Advanced: c.50% of the implant length</td>
<td>c.8 mm</td>
<td>BOP and/or suppuration</td>
<td></td>
</tr>
<tr>
<td>Sanz and Chapple2</td>
<td>Changes in the level of crestal bone</td>
<td>With or without concomitant deepening PD</td>
<td>BOP and/or suppuration</td>
</tr>
<tr>
<td>Decker et al38</td>
<td>Bone loss c.2 mm from expected bone level</td>
<td>With or without concomitant deepening PD</td>
<td>BOP and/or suppuration</td>
</tr>
<tr>
<td>Derks et al28</td>
<td>Slight/Mild: c.0.5 mm</td>
<td>Not specified</td>
<td>BOP and/or suppuration</td>
</tr>
<tr>
<td>Moderate/Severe</td>
<td>c.2 mm</td>
<td>BOP and/or suppuration</td>
<td></td>
</tr>
</tbody>
</table>

*RBL indicates radiographic bone loss; PD, probing depth; BOP, bleeding on probing.

<p>| TABLE 3 |
| Proposed multi-domain scale defining peri-implantitis* |</p>
<table>
<thead>
<tr>
<th>Proposed Multidomain Scale</th>
<th>RBL</th>
<th>PD</th>
<th>BOP and/or Suppuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>With baseline</td>
<td>Progressive bone loss c.0.2 mm annually compared to the baseline</td>
<td>Deepening PD and with progressive RBL PD consistent with concomitant RBL</td>
<td>Suppuration and/or with clinical signs of inflammation</td>
</tr>
<tr>
<td>(1 year after abutment connection)</td>
<td>Bone level implant: RBL c.2 mm from the implant platform</td>
<td></td>
<td>Suppuration and/or with clinical signs of inflammation</td>
</tr>
<tr>
<td>Without baseline</td>
<td>Tissue-level implant: RBL c.2 mm from the apical termination of the polished collar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severity</td>
<td>Slight/Mild: c.25% of the implant length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate: 25%–50% of the implant length</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advanced: c.50% of the implant length</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*RBL indicates radiographic bone loss; PD, probing depth; BOP, bleeding on probing.
Parameters to Define Peri-Implantitis

Figure A 67-year-old Caucasian female received dental implant placement to replace the missing teeth #29 and #30. (a) Periapical radiograph was taken at the time of implant placement. (b) Another periapical radiograph was taken 1 year after definite restoration. This periapical radiograph is served as a baseline radiograph to represent radiographic bone level. (c) Periapical radiograph taken 2 years after crown delivery showed progressive peri-implant bone loss at distal aspect of #29. No apparent peri-implant bone loss was seen at #30. (d) A clinical picture taken 2 years after crown delivery showed inflamed peri-implant tissue with suppuration at #29 and #30. Based on the proposed multi-domain scale, #29 was determined with peri-implantitis and #30 was determined with peri-implant mucositis.

Bleeding on Probing

The presence of BOP or suppuration is generally used as one of the criteria to define peri-implant tissue inflammation. The clinical value of BOP has been studied extensively in the periodontal literature. Lang et al44 reported that BOP is a good indicator for predicting future attachment level loss in natural dentition, with a 30% chance if BOP is present at the same site on four consecutive recall appointments. In addition, although BOP has a low positive predictive value, its negative predictive value was almost 100%, indicating that the absence of BOP is a good measure of periodontal health. It has been presumed that the same correlations apply to peri-implant tissues; however, this has not been clinically validated.46

Since peri-implant tissue is less resistant to probing forces than is the periodontium, simply using the presence of BOP may not adequately characterize the inflammatory status of the peri-implant tissues. Furthermore, previous studies have reported that BOP around dental implants was significant despite reduced signs of tissue inflammation.48,49 Therefore, because BOP does not accurately reflect the status of the peri-implant tissues, other measures (ie, redness, swelling, suppuration) are needed to evaluate the inflammatory condition around implants.

Suppuration

Suppuration is the most common parameter used with BOP to confirm the status of peri-implant tissue inflammation. Interestingly, though the value of this parameter has been investigated at periodontal sites, there is currently no standardized method to measure this parameter at peri-implant sites. In an early study, Kaldahl et al introduced the use of an egg ball burnisher to exert lateral pressure against the gingival margin to detect suppuration. A positive suppuration value was recorded if visible nonclear exudate was seen at the gingival crevice. Their study showed that gingival suppuration was a better prognosticator of future attachment loss than gingival bleeding or supragingival plaque. The authors further concluded that suppuration is an indicator of active attachment loss; however, lack of suppuration did not ensure health or the absence of breakdown.40

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With regards to peri-implant tissues, Derks et al\textsuperscript{28} reported a positive value if an observation of suppuration was noted within 15 seconds following pocket probing. Other parameters—such as the plaque index, bleeding index, or gingival index—have also been used\textsuperscript{27,29} as adjunctive criteria to determine peri-implant tissue health. Based on the current evidence,\textsuperscript{46,48–50} the presence of suppuration presumably provides a higher sensitivity for peri-implant tissue breakdown than the presence of BOP. However, further clinical trials are needed to analyze the predictive values of these parameters at peri-implant sites.

**SUMMARY**

Based upon the currently available evidence, we propose a multidomain diagnostic scale for peri-implantitis (Table 3) that incorporates the use of RBL, PD, and BOP/suppuration. In terms of RBL, if a baseline radiograph taken at the time of abutment connection is available, we recommend less than 0.2 mm annual bone loss after physiologic bone remodeling as the acceptable threshold. If a baseline radiograph is not present, a threshold of 2 mm from the expected bone level (based on bone-level or tissue-level implants) is proposed. With respect to PD, since this parameter might not reliably reflect disease status, a threshold PD is not used as a criterion. Instead, a deepening PD with progressive RBL (if a baseline PD is available) or a PD consistent with concomitant RBL (if a baseline PD is not available) is proposed as an adjunctive parameter to define peri-implantitis. The presence of suppuration remains one of the criteria to define peri-implant tissue inflammation in our scale since this parameter tends to be more sensitive than BOP for detecting tissue breakdown. However, we suggest the inclusion of other clinical signs of tissue inflammation (ie, BOP, redness, swelling) to confirm the inflammatory status around implants. A severity scale of peri-implantitis based on the percentage of RBL relative to total implant length is also included in our proposed multidomain scale.

Since there is a high prevalence of peri-implant diseases in contemporary dentistry, a generally accepted diagnostic scale is crucial to achieve consistent diagnosis and further guide clinical practice. Although our proposed scale is based on the available evidence, future investigations and modifications may be warranted; namely, a comprehensive, evidence-based classification system is needed to address the multifactorial etiology of peri-implant diseases.

**ABBREVIATIONS**

BOP: bleeding on probing
PD: probing depth
RBL: radiographic bone loss

**NOTE**

The authors report no conflicts of interest related to this study.

**REFERENCES**


