Is bleeding on probing a reliable clinical indicator of peri-implant diseases?

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Summary: BOP is dynamic in nature and should be used in addition to other parameters such as visual signs of inflammation, probing depth, and progressive bone loss before a peri-implant disease diagnosis is established.

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Author Contributions

HD, MH and HLW designed the schematic illustrations. HD, MH, AR, HG and HLW contributed to conception and design, analysis and interpretation, drafted manuscript, critically revised manuscript and gave final approval and agreed to be accountable for all aspects of work to ensuring integrity and accuracy.

Abstract

Bleeding on probing (BOP) is regarded as an indispensable diagnostic tool for evaluating periodontal disease activity, however its role in peri-implant disease is more intricate. Much of the confusion about the interpretation originates from drawing parallels between periodontal and peri-implant conditions. BOP can originate from two forms of probing in implants: traumatic or pathologic induction. This, in addition to the dichotomous scale of BOP can complicate diagnosis. The objectives of this editorial include: (1) to discuss the value of BOP as a diagnostic tool for peri-implant diseases; (2) the reasons it should be distinct from value for diagnosing periodontal and peri-implant diseases; and (3) the current best evidence on how to implement it in daily clinical practice. A comprehensive bleeding index is proposed for evaluating and monitoring peri-implant conditions.

Conclusion: BOP should be used in addition to other parameters such as visual signs of inflammation, probing depth, and progressive bone loss before a peri-implant diagnosis is established.

Key words: Dental implants, peri-implantitis, inflammation, periodontium, suppuration

Background

Pathogenesis of periodontal and peri-implant diseases can be best described as a site-specific biofilm-mediated host inflammatory response[1-3]. This varies from reversible gingival redness and edema, to irreversible alveolar bone and supporting tissue destruction of periodontal and peri-implant attachment[4,5]. Gingivitis and peri-implant mucositis are reversible inflammatory reactions that do not involve loss of supporting tissues. Gingivitis is a major risk factor for periodontal attachment loss ('periodontitis')[6]. On the other hand, if left

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untreated, peri-implant mucositis often leads to destruction of implant supporting tissues, which is now known as peri-implantitis[3]. While progression of periodontal disease is best *monitored* by clinical attachment loss[7], clinical parameters that *predict* attachment loss has been an ongoing pursuit in the last few decades[8]. Likewise, considerable efforts have been made to identify prognostic indicators for peri-implant hard and soft tissue changes[9].

In the meantime, bleeding on probing (BOP) is regarded as an indispensable diagnostic tool for evaluating periodontal disease activity. For diagnosing periodontitis, in spite of a low sensitivity of 29%, the absence of bleeding on probing is highly specific (88%) for periodontal health[10]. This means that BOP cannot detect periodontal disease presence, but its absence. Using BOP as a diagnostic tool of peri-implant disease is even more intricate, with its assessment value fluctuating between 0% to 52%[11,12]. None of the 2017 World Workshop on classification of periodontal & peri-implant diseases and conditions were based on dichotomous presence or absence of a single parameter[13]. All definitions were based on a combination of four parameters: visual signs of inflammation; BOP and/or suppuration (SUP) and the amount of bleeding; probing depth (PD); and presence of radiographic bone loss beyond initial bone remodeling. Hence, the main objective of this editorial is: (1) to discuss the value of BOP as a diagnostic tool for peri-implant diseases; (2) the reasons BOP should be distinct from value for diagnosing periodontal and peri-implant diseases; and (3) the current best evidence on how to implement BOP in daily clinical practice.

Are periodontal and peri-implant diseases the same condition?

There are certain similarities between periodontal and peri-implant diseases in terms of etiology, pathogenesis, risk factors and clinical presentation[14]. Both diseases occur due to biofilm accumulation, with very few qualitative differences in microbiota[15]. Subgingival flora around the implants harbored more pathogenic bacteria than periodontally involved teeth in the same jaw[16]. Moreover, the host response to peri-implant biofilm in peri-implant mucositis seemed to be slightly more pronounced than that seen in gingivitis[14]. In chronic periodontitis lesions, the inflammation usually remains contained within the connective tissue, while in peri-implantitis, the extent of the inflammatory cell infiltrate has been reported to extend to the bone marrow[14,17]. This may be attributed to the tissue structural differences between implants and teeth.

Conclusions: The etiology of periodontal and peri-implant diseases seems to be very similar. However, the quantity of microbiota, the host response to it, and the resulting clinical manifestations appear to be more exaggerated in peri-implant diseases.

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Probe penetration in teeth and implants during health & disease

In absence of inflammation, it was shown that the supracrestal tissue height (biologic width) provides a sufficient physical barrier or "apical stop" against probe penetration, with maximum penetration being within the junctional epithelium[18,19]. Standing in contrast is probing around the peri-implant tissue, where features of the peri-implant structures play a role in influencing both periodontal probe penetration and pocket-depth measurements. In healthy sites, when probing was compared around teeth and implants, peri-implant mucosa experienced mutually compression and lateral displacement; compared to minor compression of gingival tissue in natural teeth. In addition, the PD was deeper at implant sites compared to teeth[20]. The fundamental difference in the supracrestal fiber attachement between teeth and implants affects the probe penetration between the two structures. The connective tissue fibers in the periodontium are inserted into the root surface perpendicularly. However, the attachment of the peri-implant mucosa to the implant surface is quite different, in that there is a lack of a true attachment of the supracrestal connective tissue. Instead, the collagen fibers are oriented parallel to the implant surface[21]. It was argued that using lighter probing forces (0.2-0.25N) would lead to similar probing depths to teeth[21]. Lang and co-workers demonstrated that at sites with peri-implant mucositis, the tip of the probe was identified at the apical border of the barrier epithelium, while at sites with peri-implantitis, the measurement error was much greater at 1.5 mm[22]. This deeper penetration was attributed to the weaker soft tissue seal and potentially induced BOP in clinically healthy implants[21].

Conclusions: In absence of inflammation, the probe will penetrate slightly deeper around implants than in natural teeth, displacing the mucosa laterally, without penetrating the connective tissue barrier. With peri-implant mucositis or peri-implantitis, the probe might stop close to alveolar bone. This is usually one of the culprits for increased bleeding around diseased implants.

BOP in health & diseases

While gingival bleeding is not a diagnosis, it is an indispensable clinical parameter used for diagnostic purposes[23]. Absence of BOP suggests periodontal health[24]. Like natural teeth, BOP in implant sites is evident with inflammation and its incidence increases with severity (peri-implant mucositis vs. peri-implantitis), while absence of BOP is a strong indicator of

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peri-implant tissue stability[25]. However, it is crucial to note that in natural teeth BOP has been shown to occur in the absence of disease[24], its presence has proven to be influenced by multiple factors[26], and its frequency increases with the probing force[27]. More so for implants, a markedly high false positive rate of BOP was found when identifying peri-implantitis[28]. More relevant to the current comparison, when teeth and implants in the same patients were compared in absence of disease, BOP was significantly higher at implants than at teeth[29].

Conclusions: Presence of BOP around implants may or may not suggest ongoing inflammation, and its absence confirms health.

BOP as an indicator for disease progression

Based on several evidence, the degree to which BOP solely indicates the presence of disease, let alone risk of disease progression is entirely ambiguous. In periodontitis treated patients, it has been shown that continued absence of BOP during maintenance is an indicator of periodontal stability. Lang and co-workers reported that only 1.3% of sites that rarely had BOP (0/6 or 1/6 assessments) lost ≥2 mm clinical attachment[10]. Conversely, almost 28% of the sites that continuously had BOP (5/6 or 6/6 assessments) lost ≥2 mm clinical attachment[10]. Perhaps the key here is continued BOP or lack thereof, in lieu of a single incident of bleeding. While almost 99% negative predictability is a great indicator to rule out disease, a 28% positive predictability remains a modest predictor. Numerous longitudinal studies monitoring long term outcomes of treated and maintained periodontitis patient concluded that BOP was not a good prognosticator of attachment loss[30-33]. Correspondingly, using BOP alone to evaluate peri-implant health after surgical treatment of peri-implantitis may be misleading and must be used in conjunction with other visual inflammatory markers, degree of BOP (linear/profuse) along with clinical judgement[34]. The criteria that apply for diagnosis of peri-implant diseases before treatment should also apply for after treatment. BOP should not be used as a sole criterion for disease recurrence or failure of implant treatment. Any bone lost throughout the disease process should not be considered in the diagnosis. The key in these cases should always be progressive bone loss. A recent publication proposed a classification system of the peri-implant status after surgical treatment for peri-implantitis[34].

Furthermore, in implants, BOP can originate from two forms of probing in implants: traumatic or pathologic induction. A pathologic BOP is often induced by inflammation and could be considered as a disease indicator. BOP is a clinical parameter demonstrating the host

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response to bacterial biofilm and is always present with peri-implant disease[35]. The probability of BOP increased with increasing PD in implants especially at the interproximal sites[36]. Whereas traumatic BOP around implants is often caused by probing too hard due to difficulty gaining access for normal probing[37](Figure 1) This is attributed to the tenuous nature of the peri-implant mucosa compounded by the ability to probe around the implant made difficult by the prosthetic contours[38]. Hence, the proportion of implants presenting with BOP that was verified to have peri-implantitis fluctuated between 0%[11] to 52%[39]. On the other hand, some have even suggested that BOP alone had higher diagnostic accuracy for disease progression at implant sites than natural tooth[40]. A recent systematic review reported the proportion of peri-implantitis to be 24% in BOP-positive implants and 33.8% for BOP-positive cases, values which greatly resemble what are found in natural teeth[37]. That again means that in majority of cases, BOP was observed in the absence of peri-implantitis. Accordingly, the authors concluded that "clinicians should be aware of the considerable false-positive BOP rate to diagnose peri-implantitis"[37].

Conclusions: Absence of BOP strongly indicates health with a high negative predictive value for disease progression, but its presence does not denote disease progression either around natural teeth or implants. Clinicians should be cognizant about traumatic BOP which could be exaggerated in implants compared to natural teeth.

Impact of suppuration on BOP as a diagnostic criterion of peri-implant diseases

Recently, the presence and grade of SUP have been associated with peri-implant bone loss, probing depth, and defect morphology in patients with periimplantitis[41]. However, presence of suppuration in peri-implant mucositis is contentious. Several studies have shown that SUP was not identified in healthy implants or those exhibiting mucositis, but only in implants with peri-implantitis[41-43]. Renvert et al. in a review paper found 33 evaluated studies used the presence of BOP and/or suppuration as a defining criterion for peri-implantitis, while only two studies used suppuration for defining peri-implant mucositis[44]. Peri-implant mucositis sites that did have suppuration, harbored a microbiome with higher pathogenicity and may be more prone to progress to peri-implantitis[45]. Hence, it is important to pay attention to BOP and/or suppuration to detect any changes around dental implants, particularly because progressive peri-implant bone loss without BOP and suppuration may be an uncommon occurrence[35,46].

Conclusions: BOP with suppuration is a definitive indicator of active disease. When present, they are suggestive of a higher degree of inflammation and advanced peri-implant lesions.

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Role of BOP in monitoring peri-implant conditions

Currently, there are no reliable, universal methods to predict the progression of peri-implant disease or the transformation of peri-implant mucositis to peri-implantitis[45,47], partly due to the variance in implant design and surface characteristics and case definitions, in contrast to natural teeth. Hence, BOP plays a vital role in detecting any early changes around dental implants. But it is also important to be mindful that the dichotomous nature (presence or absence) of BOP reporting could potentially consider bleeding induced by traumatic probing, especially in the absence of other inflammatory changes, as diagnostic of peri-implant mucositis. Moreover, many studies have used different indices for evaluation of peri-implant mucosa which makes comparative analysis difficult[47-49]. So far, the index by French and co-workers seems to be the best validated, incorporating the presence and extensiveness of BOP[48,49]. However, there is still a lack of a comprehensive index for assessing and monitoring peri-implant status that utilizes not only BOP as a non-binary ordinal scale but also incorporating plaque and mucosal components, using a standardized probing pressure[47,50]. Hence, we are proposing the following peri-implant bleeding index (the probing force will be set at 0.25N) (Figure 2):

Score 0: Normal mucosa, no visible plaque and no bleeding

Score 1: Slight peri-implant mucositis, minimal plaque, minor erythema or edema with minimal visible bleeding dot

Score 2: Moderate peri-implant mucositis, visible plaque, evident erythema or edema with bleeding line or drop

Score 3: Severe peri-implant mucositis or peri-implantitis, evident plaque, severe erythema or edema with ulceration, spontaneous or profuse bleeding with or without suppuration.

While the regular 6-site BOP scoring will notify the clinician whether the peri-implant tissues are bleeding without an indication of health or disease. A multiplex index like the one suggested takes into consideration other parameters, that when coupled with BOP could indeed point to a more accurate diagnosis.

Conclusions

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BOP is dynamic in nature and may not predict disease progression. BOP should be used in addition to other parameters such as PD, progressive bone loss and visual signs of inflammation before a peri-implant diagnosis is established. The diagnosis of peri-implant diseases should be based on multiple criteria including: 1) presence of peri-implant signs of inflammation (redness, swelling); 2) BOP (line or drop of bleeding); 3) suppuration on probing/suppuration; 4) increased probing depth (PD) from baseline measurements if available; and 5) progressive bone loss following the initial physiological bone remodeling.

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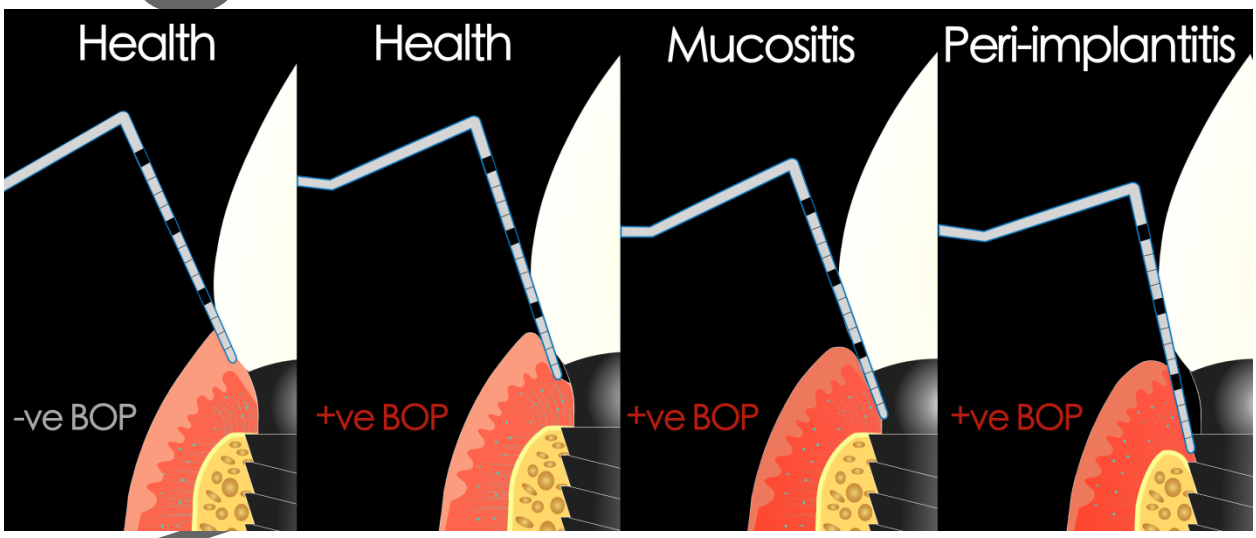
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Legends:

Figure 1: Bleeding on probing around implants in states of health and disease.

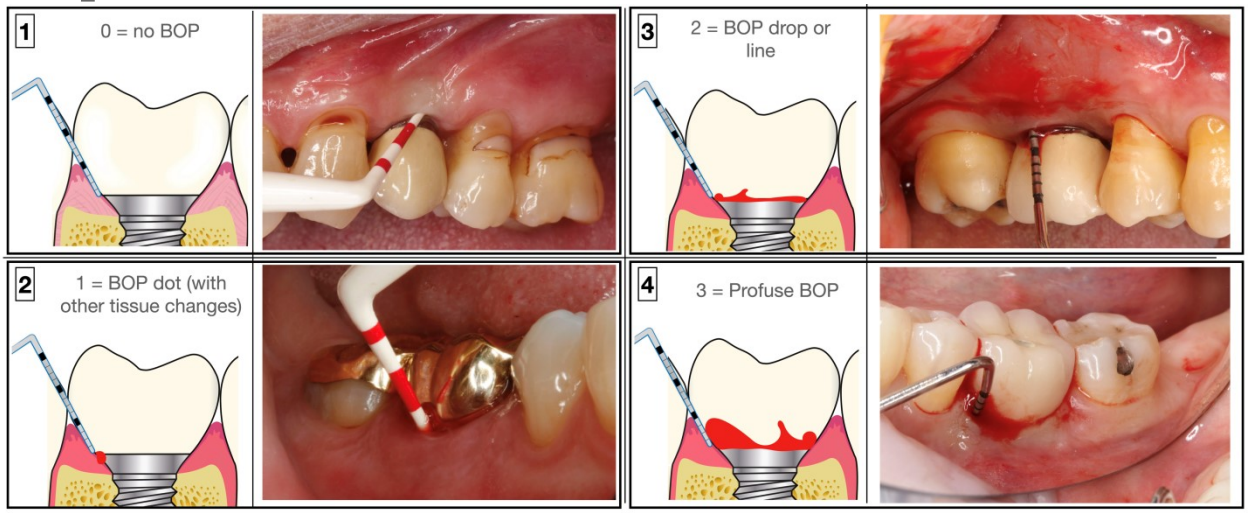
A) Probing around a healthy implant with light probing forces (≤0.25N) is usually not associated with any bleeding. **B)** A higher force on probing or a wrong probe angulation may cause bleeding around healthy implants (traumatic BOP). **C)** BOP is a common finding in peri-implant mucositis. **D)** BOP is a normal finding in peri-implantitis



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Figure 2: An illustration with matching clinical photos based on the proposed scoring index: 0 = no BOP; 1 = BOP dot (with other tissue changes); 2 = BOP drop or line; 3 = profuse BOP



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