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REVIEW ARTICLE

Risk for peri-implant diseases and defects: Report of workgroup 1 of the joint AO/AAP consensus conference on prevention and management of peri-implant diseases

Purnima S. Kumar[1] | **Joseph Kan**[2] | **Maria Elisa Galarraga-Vinueza**[3] | **Guo-Hao Lin**[4] | **Alberto Monje**[5] | **Lorenzo Tavelli**[6] | **Sandra Stuhr**[1] | **Yung-Ting Hsu**[7] | **Junying Li**[1] | **Alexandra Tsigarida**[8] | **Debora Dias**[9] | **SukirthMurthy Ganesan**[10] | **Shi Yin**[11] | **Don Curtis**[4]

[1]School of Dentistry, University of Michigan, Ann Arbor, Michigan, USA

[2]School of Dentistry, Loma Linda University, San Bernadino, California, USA

[3]School of Dentistry, Tufts University, Boston, Massachusetts, USA

[4]University of California San Francisco School of Dentistry, San Francisco, California, USA

[5]University Internacional de Catalunya, Barcelona, Spain

[6]Harvard University School of Dental Medicine, Boston, Massachusetts, USA

[7]School of Dentistry, University of Washington, Seattle, Washington, USA

[8]University of Rochester, Rochester, New York, USA

[9]School of Dental Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

[10]School of Dentistry, University of Iowa, Iowa City, Iowa, USA

[11]Private Practice, Seattle, Washington, USA

Correspondence
Purnima S. Kumar, University of Michigan School of Dentistry, 1011 N. University Avenue, Ann Arbor, Michigan 48109, USA.
Email: kpurnima@umich.edu

Purnima S. Kumar and Joseph Kan are Workgroup 1 co-chairs.

[Correction added on June 25, 2025, after first online publication: The affiliation of Author Debora Dias was revised.]

Abstract

Background: A consensus meeting on peri-implant diseases and treatment was initiated by the American Academy of Periodontology (AAP) and the Academy of Osseointegration (AO) with the goal of developing subject- and site-level risk profiles for peri-implant diseases and defects, and risk-informed treatment recommendations. This report summarizes the conclusions of Working Group 1.

Methods: Working Group 1 evaluated the risk for peri-implant diseases and defects based on four commissioned systematic reviews, followed by an in-person workshop to discuss the reviews and the inferences.

Results: Several factors emerged as risk markers for peri-implant mucositis, peri-implantitis, as well as for soft and hard tissue discrepancies and defects in the absence of disease.

Conclusion: Patient- and site-level factors can increase the odds of developing peri-implant disease or defects in soft tissue and marginal bone surrounding clinically healthy implants. Risk-informed treatment recommendations were made by the panel of experts.

KEYWORDS
bone, consensus, peri-implant diseases, peri-implant mucositis, peri-implantitis, risk, soft-tissue

Key points

- This consensus estimates risk based on both patient and site-level factors.
- Consideration must be given to modifiable and non-modifiable risk factors, and treatment modified accordingly.
- There is a lack of primary research on several topics that were considered by the consensus panel, and several gaps in knowledge still continue to exist.

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INTRODUCTION

Implant-supported restorations restore masticatory efficiency, phonetics, and esthetics to over one million individuals each year across the world. Although implants have a survival rate of nearly 95%, at least one in five patients develop peri-implant mucositis or peri-implantitis over their lifetime. Therefore, clinical practice involves a process of continual decision-making to maximize the benefits of implant supported restorations and reduce the risk of disease or complications. However, such decision-making is deeply affected by the gap between available knowledge and the data that decisionmakers would need in order to make the best therapeutic choices.

A consensus conference based on the case definitions of peri-implant mucositis and peri-implantitis as delineated by the 2017 World Workshop on Periodontal and Peri-Implant Disease Classification[1] was undertaken to facilitate risk-informed decision-making in the management of peri-implant diseases and defects. The consensus also noted that both bone loss and soft-tissue defects can occur in the absence of clinical inflammation, and therefore, these should not be confused with peri-implant diseases. The focus of the consensus was also limited to endosseous titanium or titanium-alloy implants.

METHODS

The process of building consensus on risk assessment by Group 1 was initiated by commissioning four systematic reviews on the role of (1) systemic diseases and conditions, (2) surgical- and implant-related factors, (3) prosthetic design, and (4) soft-tissue factors on the onset and/or progression peri-implant-diseases and soft-tissue/bone defects. The consensus meeting consisted of plenary sessions and structured group discussions. The discussions in Group 1 were organized in the following format:

- Presentation of evidence contained in the review articles by the Group 1 co-chairs, and critical evaluation of the strength of evidence by the group.
- Development of a draft risk profile by an independent group of scholars who were not involved with any aspect of the consensus workshop, who assessed the evidence presented in the systematic reviews, and based on the following grading system:
  - High: Evidence from high-quality studies, for example, sufficiently powered, randomized controlled trials, prospective case-control studies, etc. The evidence for the risk is high and is both statistically significant and clinically relevant (odds ratio > 2).
  - Moderate: Evidence from two or more low strength studies (e.g., small [<10 per group] sample sizes, short [<1 year] follow-up periods, case series), with consistent findings, or evidence from a single moderate-quality study (e.g., adequately powered cross-sectional study, case-control studies). The evidence for the risk is moderately high and is either statistically significant or clinically relevant (odds ratio > 2).
  - Unknown: The supporting evidence is lacking and requires the work group to make a recommendation based on expert opinion by considering the known potential harm and benefits associated with the factor.
- Initial voting within Group 1 and suggestion of amendments
- Incorporating all reasonable amendments
- Creation of targeted questions by group chairs and initial voting within Group 1
- Incorporating all reasonable amendments
- Presentation of workgroup results at the plenary session by group chairs
- Voting on targeted questions by the plenary group of 41 members
- The following grading system was adopted by Group 1 based on the German Association of the Scientific Medical Societies and Standing Guidelines Commission;[2]

  Unanimous: 100% agreement among plenary panel
  Strong consensus: Agreement ≥95% of participants
  Consensus: Agreement of 75%–95% of participants
  Simple majority: Agreement of 50%–74% of participants
  No consensus: Agreement of <50% of participants

- Modification of the risk profile based on the consensus
- Creation of decision matrices to represent a visual summary of the consensus and recommendations of the plenary group.

RESULTS

Risk markers for peri-implant soft-tissue dehiscence/discrepancies

1. Immediate implant placement increases the risk for peri-implant soft-tissue dehiscence (PSTDs)/discrepancies
   Sources of evidence: Tavelli and Barootchi[3]
   Strength of consensus: No consensus (26% agreed, 5% neutral, 70% disagreed, 1% abstained).

2. Improperly positioned implants increase the risk for the peri-implant soft-tissue dehiscence (PSTD)/discrepancies
   Sources of evidence: Tavelli and Barootchi[3]
   Strength of consensus: Consensus (90% agreed, 2.4% neutral, 7.6% abstained).

3. Placing implants in the presence of inadequate/limited KT increases the risk for peri-implant soft-tissue dehiscence (PSTD)/discrepancies
   Sources of evidence: Tavelli and Barootchi[3]

Strength of consensus: Consensus (80.5% agreed, 5% neutral, 5% disagreed, 9.5% abstained).

4. Thin mucosal phenotype increases the risk for peri-implant soft-tissue dehiscence (PSTD)/discrepancies
Sources of evidence: Tavelli and Barootchi[3]
Strength of consensus: Strong consensus (95% agreed, 2.5% neutral, 2.5% abstained).

Risk markers for peri-implant marginal bone loss

1. Splinted implants are associated with a higher risk for developing peri-implant marginal bone loss
Sources of evidence: Lin et al.[4]
Strength of consensus: Consensus (80% agreed, 9.7% disagreed, 7.3% neutral, 2.4% abstained)

2. Platform-switched abutments are associated with a decreased risk for developing for peri-implant marginal bone loss
Sources of evidence: Lin et al.[4]
Strength of consensus: Consensus (85.3% agreed, 9.8% disagreed, 4.9% abstained)

3. Transmucosal abutment height of ≥2 mm is associated with a lower risk for developing peri-implant marginal bone loss
Sources of evidence: Lin et al.[4]
Strength of consensus: Consensus (85% agreed, 5% neutral, 5% disagreed, 5% abstained)

4. Transmucosal emergence angle > 30^0 is associated with an increased risk for developing peri-implant marginal bone loss
Sources of evidence: Lin et al.,[4] long-term evidence on marginal bone levels is currently lacking. Unable to arrive at data-driven risk estimate.
Strength of consensus: Consensus (92% agreed, 8% disagreed)

5. Convex implant abutment profile is associated with an increased risk for developing peri-implant marginal bone loss
Sources of evidence: Lin et al.,[4] long-term evidence on marginal bone levels is currently lacking. Unable to arrive at data-driven risk estimate.
Strength of consensus: Consensus (92% agreed, 5% neutral, 3% disagreed)

6. Concave implant abutment profile is associated with a lower risk for peri-implant marginal bone loss

   Sources of evidence: Lin et al.,[4] long-term evidence on marginal bone levels is currently lacking. Unable to arrive at data-driven risk estimate.
   Strength of consensus: Consensus (78% agreed, 16% neutral, 5% disagreed, 1% abstained)

7. The implant abutment/prosthetic interface when placed in close proximity to the bone leads to marginal bone loss
Sources of evidence: Lin et al.,[4] long-term evidence on marginal bone levels is currently lacking. Unable to arrive at data-driven risk estimate.
Strength of consensus: Consensus (83% agreed, 5% neutral, 5% disagreed, 7% abstained)

Risk markers for peri-implant mucositis

1. Soft tissue phenotype plays a role in the risk for peri-implant mucositis
Sources of evidence: Monje et al.[5]
Strength of consensus: Consensus (83% agreed, 5% neutral, 12% abstained).

2. Obesity is associated with a higher risk for mucositis
Sources of evidence: Galarraga-Vinueza et al.[6]
Strength of consensus: Simple majority (61% agreed, 29% neutral, 10% disagreed).

Risk markers for peri-implantitis

1. Peri-implant mucositis is predisposing factor for the development of peri-implantitis
Sources of evidence: Lin et al.[4] and Monje et al.[5]
Strength of consensus: Consensus (80.5% agreed, 2.5% disagreed, 27% abstained)

2. Soft-tissue phenotype plays a role in the risk for peri-implantitis
Sources of evidence: Tavelli and Barootchi[3] and Monje et al.[5]
Strength of consensus: Consensus (80.5% agreed, 2.5% disagreed, 17% abstained)

3. Implants placed in regenerated bone are more susceptible to peri-implantitis
Sources of evidence: Lin et al.[4] and Monje et al.[5]
Strength of consensus: No consensus (36.5% agreed, 12% neutral, 46.5% disagreed, 5% abstained)

4. Inadequate mesio-distal inter-implant distance is a risk for peri-implantitis
Sources of evidence: Lin et al.[4] and Monje et al.[5]
Strength of consensus: Consensus (93% agreed, 2% neutral, 5% abstained)

5. Implant macro- and micro-design influence the risk of onset/progression of peri-implantitis
Sources of evidence: Lin et al.[4] and Monje et al.[5]
Strength of consensus: Consensus (93% agreed, 2% neutral, 5% abstained)

6. Hypertension is associated with a higher risk for peri-implantitis
Sources of evidence: Galarraga-Vinueza et al.[6]

Strength of consensus: No consensus (34% agreed, 32% neutral, 34% abstained)

7. Uncontrolled or poorly controlled diabetes mellitus is associated with a higher a risk for peri-implantitis
   Sources of evidence: Galarraga-Vinueza et al.[6]
   Strength of consensus: Strong consensus (95% agreed, 2.5% neutral, 2.5% abstained)
8. Obesity is associated with a higher risk for peri-implantitis
   Sources of evidence: Galarraga-Vinueza et al.[6]
   Strength of consensus: No consensus (44% agreed, 31% neutral, 20% disagreed, 5% abstained)
9. History of periodontitis is a risk factor for peri-implantitis
   Sources of evidence: Galarraga-Vinueza et al.[6]
   Strength of consensus: Consensus (90% agreed, 5% neutral, 5% abstained)
10. Depression and antidepressants are associated with a higher risk for peri-implantitis
    Sources of evidence: Galarraga-Vinueza et al.[6]
    Strength of consensus: Strong consensus (95% agreed, 2.5% neutral, 2.5% abstained)

The subsequent sections present a tool-kit for assessing risk of soft-tissue defects, peri-implant marginal bone loss, peri-implant mucositis, and peri-implantitis. The purpose of these trees is to provide an evidence-based overview of variables that can negatively impact implant outcomes for a particular patient or site, and recommendations for mitigating the risk posed by them.

Risk of peri-implant soft-tissue defects and deficiencies in clinically healthy sites

Soft-tissue dehiscence, deformities, and defects at implant sites are increasingly becoming a clinical concern due to high esthetic expectations of patients (Figure 1). While they were initially considered to be counterparts of gingival recessions on natural teeth, it is becoming apparent that unlike teeth where shallow recessions are not always associated with esthetic concerns, even a minimal soft-tissue dehiscence exposing the titanium surface of the implant/abutment can alter a patient's perception of successful implant therapy. Here, we describe three types of soft-tissue defects surrounding healthy implants: Peri-implant soft-tissue dehiscence (PSTD)—apical position of the peri-implant soft-tissue margin in relation to the anatomical cemento-enamel junction of the homologous contralateral tooth, Mucosal recession (MREC): presence of a mucosal cleft that exposes the implant shoulder, prosthetic abutment, or implant surface, and Apical shift of the mucosal level (ML). Progressive apical shift of the soft-tissue margin over time compared to the position of the ML at crown delivery.

The mean incidence of PSTD after 1 year was 33.3%, and between 3 and 5 years, it was found to be 38.3%.[3] After 5 years, the mean incidence of PSTD was 64.5%. The mean incidence of MREC between 1 and 3 years was 47.8%, and 45.7% between 3 and 5 years. The mean incidence of ML changes was 15.3% within the first year, and 35.1% >5 years. The mean PSTD, MREC, and ML changes within 1 year were 0.33, 0.39, and 0.37 mm, respectively, while they increased by 0.5–1.0 mm within 3 years. Figure 1 summarizes the factors that increase risk for these defects, and recommendations to mitigate/prevent/reduce this risk.

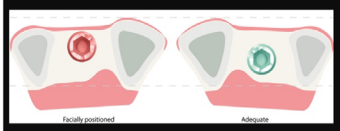
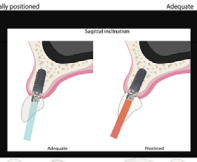
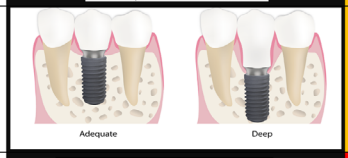
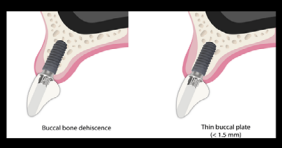
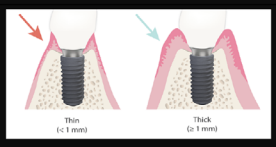
It must be noted that the plenary panel did not reach consensus on some of the variables presented in the risk matrix. Notable among these was the impact of immediate implant placement on the incidence of soft-tissue defects. The panel considered the evidence but pointed out that several ancillary factors can influence the outcome, for example, the depth of implant placement, whether the site is tooth/implant bounded, as well as soft and bone tissue characteristics (width and thickness of bone and keratinized tissue (KT), and width and height of bony dehiscence). These factors co-occur with, but are not a result of immediate implant placement; therefore, more studies are needed to distinguish the relative contributions of these factors. Similarly, the plenary panel noted that the number of years in function might involve other factors such as loss of additional teeth, presence of restorations, changes in oral hygiene habits, etc., which might confound the results. The panel strongly agreed that thin mucosa/phenotype and buccally positioned implants have a high risk of developing esthetic complications.

Risk for peri-implant marginal bone loss in the absence of clinical disease

Following functional loading, the marginal bone surrounding the implant undergoes physiological remodeling (Figure 2). At the end of this process, a supracrestal attachment is established which contributes to stable implant health and function. Several factors can cause this process to be disrupted and result in continued marginal bone loss. The significance of early/initial marginal bone loss lies in the increased susceptibility to the subsequent development of peri-implant diseases. As such, the greater the bone loss during the establishment of the supracrestal adhesion, the greater are the odds to develop peri-implantitis in the long term.

Lin et al.[4] demonstrate that the risk for peri-implant bone loss is multifactorial and includes both prosthetic design and surgical aspects. On the other hand, the factors that protect against marginal bone loss are sufficient buccal/lingual bone thickness to ensure that (1) the implant is

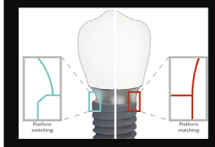
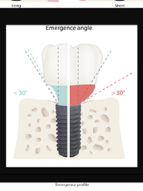
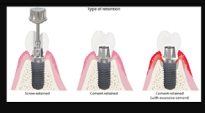
Peri-implant soft tissue defects and deficiencies in clinically healthy sites

Risk marker		Risk level	Evidence	Stat sig	Clin sig	Consensus	Clinical consideration
Facially positioned implant		High	4 Cross-sectional, 2 , prospectivenon-RCTs, and descriptive studies **Qual analysis**	✅	✅	✅	🔷Ideal prosthetically driven implant positioning is critical
Sagittal implant angle "proclined/ angled"		Moderate	1 Cross-sectional, **Qual analysis**	✅		✅	
Implant platform >6mm below adjacent CEJ		Moderate	1 Cross-sectional, **Qual analysis**	✅	✅	✅	🔷Identify and correct thin buccal bone and dehiscence defects prior to or concomitant with implant placement
Convex emergence profile		High	2 Cross-sectional, 1 prospective non-RCT, and descriptive studies, **Qual analysis**	✅	✅	✅	
Buccal bone dehiscence		High	2 cross-sectional studies, case series, 2 Prospective non-RCTs, **Qual analysis**	✅	✅		🔷Delayed implant placement
Keratinized tissue width <2mm		High	27 RCT, 15 prospective non-RCTs, **Stat analysis** 8 Cross-sectional and prospective studies,**Qual analysis**	✅	✅	✅	🔷 Flapless and guided surgical approach 🔷Soft tissue augmentation prior to or concomitant with implant placement.
Thin facial mucosa		High	16 RCTs,11 prospective non-RCTs **Stat analysis** 14 Cross-sectional and prospective studies, **Qual analysis**	✅	✅	✅	
Immediate implant placement		Moderate	93 studies, 42 RCTs, 51 prospective non-RCTs, **Stat analysis**	✅			
Interproximal marginal bone loss		High	87 studies, 40 RCTs, 47 prospective non-RCTs, **Stat analysis.** 2 cross-sectional, 1 prospective non-RCT, **Qual analysis**	✅	✅		
> 5 years in function		Moderate	1 Cross-sectional study, **Qual analysis**	✅	✅		🔷 Maintaining interproximal bone levels over time

Stat Sig– Statistical Significance
Clin Sig– Clinical Significance

FIGURE 1 Peri-implant soft-tissue defects and deficiencies in clinically healthy sites. CEJ, cemento enamel junction; Clin sig, clinical significance; RCT, randomized control trial; Stat sig, statistical significance.

Peri-implant marginal bone loss in the absence of clinical disease

Risk marker		Risk level	Evidence	Stat sig	Clin Sig	Consensus	Clinical consideration
Splinted Implant Restorations		Moderate	8 studies, RCTs, Retrospective Case Series, Cross-Sectional, **MA**	✅	✅	✅	🔹Inter-implant distance should be ≥ 3mm 🔹Minimize, whenever possible, the number of implants
Platform-matched abutments		High	21 studies, RCTs, Retrospective Case Series, **MA**	✅	✅	✅	
Transmucosal abutment height of <2mm		High	12 studies, RCTs, Retrospective Case Series, **MA**	✅	✅	✅	🔹Applies to bone-level implants 🔹An implant placed too shallow makes it impossible to choose an abutment height > 2mm
Transmucosal emergence angle >30^0		Moderate	2 studies. However, long term Evidence on MBL is currently lacking, **no MA**	✅	✅	✅	
Convex emergence profile		Moderate	2 studies. However, long term Evidence on MBL is currently lacking, **no MA**	✅	✅	✅	
Excess retained cement		High	6 studies, RCTs, Retrospective Case Series, **MA**	✅	✅		🔹Screw-retained crowns are preferred 🔹Use zinc oxide or glass ionomer cement for cement-retained restorations 🔹Excessive cement must be removed

Stat Sig– Statistical Significance
Clin Sig – Clinical Significance
MA- Meta Analysis

FIGURE 2 Peri-implant marginal bone loss in the absence of clinical disease. Clin sig, clinical significance; MA, meta-analysis; RCT, randomized control trial; Stat sig, statistical significance.

placed in a restoratively optimal position and (2) the fixture is circumferentially encased in adequate bone.

Another important factor that contributes to decreasing the risk for marginal bone loss and subsequent peri-implant disease is sufficient space to create a harmonious emergence profile and angle. In order to achieve this, it is necessary to ensure adequate mesio-distal distance between an implant and adjacent tooth/implant, optimal apico-coronal placement of the implant platform, appropriate critical and subcritical contours, abutment height, and platform characteristics. Transmucosal abutment height of 2 mm or greater provides soft-tissue support, creates space for adequate supracrestal tissue adhesion, and enables access for removal of the inflammatory infiltrate at the implant connection. These factors also facilitate self-performed oral hygiene measures. This is especially important in patients with limited manual dexterity, poor oral hygiene, or periodontal disease.

Risk markers for peri-implant mucositis

Meta-analyses of peri-implant mucositis revealed a weighted mean patient level incidence of 46% (95% confidence interval [CI] 25%–68%) within 5 years, 61% (95% CI 56%–65%) within 10 years, and 53% (95% CI 36%–65%) within 20 years (Figure 3).[6]

Several local as well as systemic factors can play a role in increasing the risk for peri-implant mucositis. Among the systemic/environmental factors, smoking, diabetes,

Peri-implant mucositis

Risk marker	Risk level	Evidence	Stat sig	Clin Sig	Consensus	Clinical consideration
Soft tissue phenotype	Moderate	8 studies, RCTs, Retrospective Case Series, Cross- Sectional, **MA**	✅	✅	✅	🔹 Closely monitor soft tissue characteristics and their influence on peri-implant health at regular intervals. 🔹 Consider soft tissue augmentation prior to or during implant placement.
Alcohol consumption(> 7 U/week for women, > 14 U/ week for men)	Moderate	3 studies - 1 cross sectional study, 1 retrospective study, 1 case control study, **MA**	✅	✅		🔹 Recommend quitting alcohol consumption before and after surgery 🔹 Provide resources for alcohol cessation counselling
Current or former smoking (<10 years of quitting)	High	9 cross-sectional studies, 2 prospective cohort and interventional studies; **MA**	✅	✅		🔹Advise cessation, provide support for quitting prior to implant therapy and/or during supportive care, and consider smoking status in implant treatment planning. 🔹Smoking cessation should be strongly recommended prior to implant placement 🔹Regular follow-ups and rigorous oral hygiene protocols are critical for smokers to prevent peri-implant mucositis.
History of periodontitis	High	5 cross-sectional studies, 3 prospective cohort and interventional studies; **MA**	✅	✅	✅	🔹Consider these patients as higher risk profile and select the implant and restorative components accordingly 🔹Patients should undergo thorough periodontal treatment and achieve disease stability before implant placement. 🔹Long-term maintenance programs and frequent monitoring are essential to manage the risk of recurrence.
Active periodontitis	High	4 cross-sectional studies; **MA**	✅	✅		🔹 Patients should undergo thorough periodontal treatment and achieve disease stability before implant placement. 🔹 Long-term maintenance programs and frequent monitoring are essential to manage the risk of recurrence.
Obesity and/or Metabolic Syndrome	Moderate	3 cross-sectional studies; **MA**	✅	✅		🔹Monitor weight and promote healthy lifestyle changes as part of implant therapy. 🔹Close attention should be given to peri-implant maintenance and monitoring for signs

Stat Sig– Statistical Significance
Clin Sig – Clinical Significance
MA- Meta Analysis

FIGURE 3 Peri-implant mucositis. Clin sig, clinical significance; MA, meta-analysis; RCT, randomized control trial; Stat sig, statistical significance

depression (and certain antidepressant medications), and obesity have emerged as putative risk indicators.[3] Smoking is known to impact mucosal barrier function, mammalian immune functions, as well as the oral microbiome,[7] especially the microbiota in the peri-implant sulcus.[8] Galarraga-Vinueza et al.[6] identified a statistically significant association between peri-implant mucositis and current and former smoking (effect summary: odds ratio [OR] 1.47, 95% CI 1.06–2.07, I^2 = 63.7%, Egger test p = 0.8742); however, hyperglycemia did not emerge as a significant risk marker (effect summary: OR 1.54, 95% CI 0.9–2.64, I^2 = 82.3%, Egger test p = 0.0040). Interestingly, obesity and alcohol consumption emerged as significant risk indicators (effect summary: OR 3.29, 95% CI 1.75–6.17, I^2 = 1.93%, Egger test

$p = 0.7166$; and effect summary: OR 2.07, 95% CI 1.49–2.85, $I^2 = 0.0\%$, Egger test $p = 0.271$, respectively).

Risk of peri-implantitis

Meta-analyses of peri-implantitis revealed a weighted mean patient level incidence of 12% (95% CI 7%–19%) within 5 years, 14% (95% CI 9%–20%) within 10 years, and 22% (95% CI 11%–36%) within 20 years (Figure 4). The highest incidence rates were reported in patient populations with history of periodontitis, fully edentulous, and erratic maintenance compliers.

Several local as well as systemic factors can play a role in increasing the risk for peri-implantitis. Among the systemic/environmental factors, smoking, diabetes, depression (and certain antidepressant medications), and obesity have emerged as putative risk markers. Smoking is known to impact mucosal barrier function, mammalian immune functions, as well as the oral microbiome, especially the microbiota in the peri-implant sulcus. The systematic review revealed that smoking is statistically significantly associated with peri-implantitis (effect summary: OR 2.27, 95% CI 1.68–3.06, $I^2 = 65.2\%$, Egger test $p = 0.4827$).

Type 2 diabetes mellitus is a disease resulting from a combination of peripheral insulin resistance, inadequate insulin secretion, and poorly regulated glucagon secretion; and is characterized by hyperglycemia.[9] Glycemic control is considered to be inadequate when fasting glucose levels are above 126 mg/dL or HbA1c levels are greater than 7%. Galarraga-Vinueza et al.[6] identified a statistically significant association between peri-implantitis and diabetes mellitus (effect summary: OR 2.31, 95% CI 1.59–3.32), $I^2 = 9.88\%$, Egger test $p = 0.2835$).

Depression and chronic stress have deleterious effects on the immune system and can impact implant health by creating an imbalance in the microbiome and neurobehavioral factors. In the present systematic review, depression was significantly associated with peri-implantitis (OR = 2.04, 95% CI 1.067–3.8, $p = 0.03$).

Periodontitis and peri-implantitis share some common immuno-inflammatory pathways in their etiopathogenesis. While active periodontitis can contribute to an exaggerated inflammatory reaction during implant integration and subsequent function, the tissue destruction that occurs as a sequela of periodontitis can also contribute to elevating the risk for peri-implantitis. Thus, periodontitis, both active disease and a history of disease experience, can enhance the risk for peri-implantitis. Galarraga-Vinueza et al.[6] report that active periodontitis was significantly associated with peri-implantitis (effect summary: OR 4.05, 95% CI 3.06–6.35, $I^2 = 1.4\%$, Egger test $p = 0.5805$). Three similar longitudinal studies reported significant peri-implantitis incidence rates for a population diagnosed with a history of periodontitis over 3–20 years.

Among the local (or site-specific) factors, peri-implant mucositis was reported as a precursor to peri-implantitis, and three-dimensional implant position, adequacy of the bone support, interimplant distance, distance between implant platform, and the bone crest play a role by influencing the biomechanics of bone that supports a functioning implant as well as the patient's ability to maintain the implant and surrounding tissues in a state of health. Figure 4 explores the factors that increase risk for this disease and recommendations to mitigate/prevent/reduce this risk.

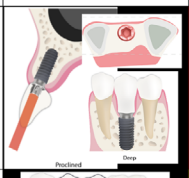
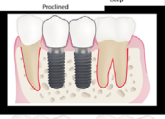
CONCLUSION

Implants have restored masticatory function to more than 100 million individuals and continue to grow at an annual rate of 15%. However, dysbiosis-driven inflammatory diseases are common and may threaten the longevity of implant-supported prostheses.[10] In particular, peri-implantitis is a highly aggressive and rapidly destructive process, which follows a nonlinear and aggressive path of progression. Interestingly, epidemiological studies demonstrate that it is a site-specific condition.[11] Consequently, local predisposing factors play key roles in the onset/progression of the disorder. Treatment of peri-implant disease accounts for substantial dental care costs, and implant loss creates a negative impact on the patient's quality of life. Therefore, the goal of this consensus was to provide an evidence-based list of factors that increase the risk for disease. The meta-analyses, systematic reviews, and consensus panel discussions all point to the critical importance of case selection and treatment planning in reducing the risk for future disease. However, the consensus meeting also identified several gaps in the literature, notably long-term studies, randomized control trial (RCTs) that are adequately powered and conducted over periods longer than 12 months, and studies on the efficacy of long-term maintenance therapy. The consensus panel also identified a need to disseminate this knowledge at various levels, beginning with creating a unified dental school curriculum for implant therapy. The consensus panel also advocated for journals and publishers to ensure that nonaggregated primary data supporting the study be available on the public domain. Further studies are needed on defining metrics of health and composite measures that measure disease resolution with a high degree of sensitivity and specificity.

AUTHOR CONTRIBUTIONS

Purnima S Kumar: Overall design; consensus question development; analysis and manuscript writing. **Joseph Kan**: Overall design; consensus question development and critical review of manuscript. **Maria Elisa Galarraga-Vinueza**: Manuscript writing, with special focus on decision tree on peri-implant mucositis and peri-implantitis. **Guo-Hao Lin**: Manuscript writing, with special focus on

Peri-implantitis

Risk marker		Risk level	Evidence	Stat sig	Clin Sig	Consensus	Clinical consideration
Implant malposition		high	1 cross-sectional study, 4 retrospective studies, **MA**	✅	✅	✅	◆ Proper treatment planning, with emphasis on prosthetically-driven implant placement surgery ◆ Perform bone regeneration whenever needed to augment the buccal bony wall (≥1.5mm)
Inter-Implant distance <3mm		Moderate	1 retrospective study		✅	✅	◆ Inter-implant distance >3mm
Implant>6mm apical to adjacent teeth		Moderate	1 retrospective study	✅	✅	✅	◆ Consider narrow diameter implants whenever suitable with the emergence profile ◆ <6mm apico-coronal distance from adjacent tooth ◆ Consider bone regeneration to create adequate bone volume for optimal implant position
Placement of implant in limited width bone		Moderate	1 retrospective cross-sectional study	✅	✅	✅	◆ Consider narrow diameter implant ◆ Consider future bone remodeling during treatment planning
Close proximity of the implant abutment/prosthetic interface to the bone		Moderate	1 retrospective study	✅	✅	✅	◆ Use tissue level implant or transmucosal abutment
Implant macro design (threaded, parallel-wall, tapered, tissue- or bone-level)		Moderate					
Uncontrolled diabetes		High	10 studies - 8 cross sectional studies, 2 retrospective studies **MA**	✅	✅	✅	◆ Blood sugar levels should be well-controlled before and after implant placement. ◆ Close collaboration with the patient's primary care provider is essential. ◆ Rigorous oral hygiene and frequent monitoring are crucial for diabetic patients.
Current smoking		High	9 cross-sectional studies, 2 prospective cohort and interventional studies; **MA**	✅	✅	✅	◆ Advise cessation, provide support for quitting, and consider smoking status in implant treatment planning. ◆ Smoking cessation should be strongly recommended prior to implant placement ◆ Regular follow-ups and rigorous oral hygiene protocols are critical for smokers to prevent peri-implant mucositis.
History of periodontitis		High	11 studies - 5 cross sectional studies,5 retrospective studies, 1 prospective clinical study, **MA**	✅	✅	✅	◆ Patients should undergo thorough periodontal treatment and achieve disease stability before implant placement. ◆ Long-term maintenance programs and frequent monitoring are essential to manage the risk of recurrence.
Active periodontitis		High	MA: 22 studies -12 cross sectional studies, 6 retrospective studies, 1 prospective cohort study,1 case control study, 1 longitudinal case series	✅	✅	✅	◆ Patients should undergo thorough periodontal treatment and achieve disease stability before implant placement. ◆ Long-term maintenance programs and frequent monitoring are essential to manage the risk of recurrence.
Obesity and/or Metabolic Syndrome		Moderate	3 cross-sectional studies; **MA**	✅	✅	✅	◆ Monitor weight and promote healthy lifestyle changes as part of implant therapy. ◆ Close attention should be given to peri-implant maintenance and monitoring for signs
Depression or anti-depressant medication		Moderate	3 cross-sectional studies; **no MA**	✅	✅	✅	◆ Recognize the signs of depression or chronic stress and modify treatment accordingly ◆ Delay implant placement until amelioration of symptoms ◆ Increase maintenance frequency

Stat Sig– Statistical Significance
Clin Sig – Clinical Significance
MA- Meta Analysis

FIGURE 4 Peri-implantitis. Clin sig, clinical significance; MA, meta-analysis; RCT, randomized control trial; Stat sig, statistical significance.

decision tree on peri-implant hard tissue defects. **Alberto Monje**: Manuscript writing, with special focus on decision tree on peri-implant hard tissue defects. **Lorenzo Tavelli**: Manuscript writing, with special focus on decision tree on peri-implant soft tissue defects. **Sandra Stuhr**: Manuscript writing, with special focus on decision tree on peri-implant soft tissue defects. **Yung-Ting Hsu**: Manuscript writing, with special focus on decision tree on peri-implant soft tissue defects. **Junying Li**: Manuscript writing, with special focus on decision tree on peri-implant hard tissue defects. **Alexandra Tsigarida**: Manuscript writing, with special focus on decision tree on peri-implant hard tissue defects. **Debora Dias**: Manuscript writing, with special focus on decision tree on peri-implant mucositis and peri-implantitis. **SukirthMurthy Ganesan**: Manuscript writing, with special focus on decision tree on peri-implant mucositis and peri-implantitis. **Shi Yin**: Manuscript writing, with special focus on decision tree on peri-implant hard tissue defects. **Don Curtis**: Critically reviewed the manuscript. All authors critically reviewed the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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